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Commanding Officer .... CAPT John M. Evans, USN
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93-02

In This Issue. . .

The East German Research Landscape in Transition:

Information for Scientific Interaction with East Germany, Including Surveys on the Structure of Research in the Federal Republic of Germany

by Hans and Lotte Dolezalek. Hans Dolezalek was the Liaison Scientist for Oceans and the Atmosphere at the Office of Naval Research European Office. He is currently a Scientific Officer in the Ocean Technology Division at the Office of Naval Research, Arlington, Virginia.

PREFACE

This report provides information to enhance scientific interaction with researchers in reunified Germany. It briefly describes the history of the Germany research structure, outlines its present status, and presents the main features of the resurrection of this structure.

The present report is an extraction from a large report, issued in three parts, that contains more information; greater detail; descriptions of agencies, organizations, and institutes (including their scientific activities and in-depth listings and addresses of points of contact); a variety of discussions; and other information. These reports, published by and available from the Office of Naval Research European Office, are:

- The East German Research Landscape in Transition. Part A: Status and Transition, ONREUR Report 93-2-R
- The East German Research Landscape in Transition. Part B: Non-university Institutes, ONREUR Report 93-3-R
- The East German Research Landscape in Transition. Part C: Research at East German Universities, ONREUR Report 93-4-R.

These are referred to in the current report as "our Report, Part..."

This report restricts its consideration to basic research in the natural sciences and engineering, and the authors evaluate overall quality and differences from American approaches. After a brief Background and Introduction, major topics addressed in this report are:

- Research in Germany
- Agencies and Organizations That Support Research
- Annotated Statistics
- Collections of Research Done or in Progress
- American/German Exchange and Collaboration.

These are followed by an extensive Discussion that includes Basic Ideas in American/German Collaboration, General Level of Science in Germany, Research Institutes in East Germany, the Situation after Transition, Practical Hints, and Conclusions. Three appendixes provide information that will be helpful for travel in the FRG.

Acknowledgments

This report reflects an effort to collect information from many sources; any attempt to

acknowledge them all would produce a list of hundreds of names and would include personal meetings, telephone conversations, correspondence, and intensive reading. We simply say, this report was made possible with the assistance of many colleagues, compiled by Hans Dolezalek, and benefited from essential collaboration in travel, visits, collecting, writing, and pre-editing by Lotte Dolezalek. Without exception, all institutions and persons contacted responded positively and cheerfully to our sometimes time-consuming requests in a cooperative spirit.

BACKGROUND

Progress in the hard sciences in Europe, as identified with individual researchers and institutes, was generally familiar to American scientists and science administrators. This also applied more or less to the former Soviet Union. Information was obtained from publications, conferences, and, to a large degree, from the work of the European representatives of the Research Offices of the U.S. Navy, Army, Air Force, and National Science Foundation. An understanding of the structure of research and the organization of scientific institutions in these countries was and is much less common.

With regard to the former German Democratic Republic (GDR), however, both scientific achievements and the structure of research remained a largely unknown territory. According to colleagues living there, this was the result of several factors. Chief among these was Gründlichkeit (the German mindset) by which the government in East Berlin stringently regulated contacts with the West. American scientists could travel relatively easily and visit colleagues in the GDR; however, after they returned, they seldom shared their newly obtained information with a wider circle. For Europeans, such travel was more difficult, especially for West Germans; getting access to a research institution was often nearly impossible. Very little free exchange of on-going research within and without the GDR was available.

Thus, because no news of scientific progress was available, it was often assumed that no research worth noting was being pursued in the GDR. This was further confirmed by the fact that industrial products coming from the GDR were often of low quality, that the infrastructure was known to be deficient, and that living conditions were bad. Therefore, the opinion prevailed that whatever scientific research there might be, it would be mediocre at best.

Both assumptions turn out to be wrong. Factually, the GDR scientists who were allowed to travel to the West were not always the best experts in the field they were expected to represent. Hard currency was not available for page charges for contributions in prestigious Western journals. Correspondence was censored and often did not arrive at its destination. Close contacts with the West subjected East German researchers to suspicion and pressure from the government. In the Eastern Bloc countries, however, it was well known that East Germany had a large research community, and that research done there was often superior to that pursued in their countries. To study at a East German university was a highly cherished privilege.

For scientists in the GDR, to be successful under the existing conditions demanded not only strong scientific morale but also inventiveness to build their own instruments, which could not be bought from the West. An insufficient knowledge of scientific progress in Western countries led to hypothesis developments on some barely known truths. Approaches to programming had to be found in spite of the shortcomings of the Robotron computers in use there.

The true quality of the research was not systematically assessed before 1990. However, the work of the few scientists who escaped from the GDR to work in Western countries proved to be equal to that of their Western colleagues within a very short time. With reunification and the opening of the borders a concerted Western assessment was put into motion. Careful scientific evaluation by the West German Science Council yielded excellent results in many cases. Visiting American scientists returned with the opinion that many of their colleagues were on equal footing with the

West or, because of their special skills and a strong motivation, would catch up quickly.

The increasing diversification of science generates everywhere a strong momentum for international cooperation. This creates a need for accurate information about both world-wide scientific achievements and organizations that support science. This information must include information about the interest and potential in these organizations for international cooperation.

German reunification offered a chance to learn about the research potential in the former GDR. Because the scientific assessment and all reorganization of this potential was and is mainly undertaken by the existing West German establishment, any meaningful study of the East German situation must include sufficient knowledge of this establishment. Accordingly, the information in this report was gathered through visits and correspondence with agencies and institutions in both West and East Germany.

In presenting the results of this investigation, we attempt to provide sufficient information for building contacts between American and German scientists and scientific institutions, either to exchange ideas or to test possibilities for scientific collaboration. Where providing such information would require too much space in this report, we note where further details can be obtained.

Avenues for a strong increase in mutually beneficial interaction may already exist, at least in part, but sometimes these are not well known. This report and the more detailed reports available from ONR Europe attempt to fill this void.

INTRODUCTION

If we want to solve the scientific problems of our time, international interaction is unavoidable. The Office of Naval Research, with its branch offices in Europe and Asia, is not alone in recognizing this. In 1991 the Federal Republic of Germany (FRG) established a Coordination Center European Community in Bonn and in Brussels, which maintains close contacts with its sister organizations in the United Kingdom (U.K.) and France. The German Center lists as its main objectives:

- providing in a quick and efficient manner specific information on the possibilities of the Research-Promotion Programs of the European Community (EC),
- responding in competent and expert ways to questions on research promotion by the EC,
- establishing a contact facility in Brussels for the German scientific world, equipped as necessary for this task,
- providing a forum where German scientists can meet European colleagues and representatives of the cognizant organizations of the EC in the course of preparing and performing EC Research Programs, and
- helping to find suitable partners for contacts.

Although its efforts are restricted to inter-European contacts, it obviously reflects a more general need. Because of the German reunification, objectives similar to these, applied to scientific relations between the U.S. and FRG (in particular East Germany), have become a challenge. This report, together with the more-detailed reports described previously, tries to respond to it.

German research in the transition years 1990 to 1992 reflects a period of continuous change. The "research landscape," as it is often referred to, is shifting; very much so in the five new länder and in East Berlin. The organization of their institutions is undergoing many changes, ranging from repeated changes of their names to direct effects on personnel at all levels and in many cases their scientific programs. Organizations, institutes, and individuals entering into negotiations with their counterparts in the five new länder and East Berlin should be aware of some shortcomings.

In the FRG, the term "land" (plural "länder") instead of "state" is used for its subdivisions. This also avoids confusion with the American term "state". The "land" is a smaller entity, having a different kind of autonomy versus the federal government, and with different relations to its counties and towns. The now-16 German länder (including the three city-districts of Berlin, Hamburg, and Bremen) have their own governments and elected parliaments. The länder are responsible for cultural and educational affairs—including

universities. Research institutes are imbedded in several different organizational forms, which often include the federal and/or land government.

This region has been under totalitarian regimes for almost 60 years. The physical condition of its cities and towns is generally bad; hotel accommodations are improving but still difficult; telephone connections are sometimes hard to establish; and traffic is slow because of deteriorating roads and railbeds and because of ongoing reconstruction.

The entire infrastructure is struggling to meet the new demands (but, more importantly, there is no doubt that the new länder will catch up with the West). However, these shortcomings do not apply to all aspects of public life. Some domains are in much better shape than the rest. These are predominantly the sciences—from mathematics to physics, chemistry, biology, medicine. This comes as a surprise to many Westerners, because until reunification very little was known about East German research.

The research structure in the five new länder cannot be understood without sufficient knowledge of the situation in West Germany. Therefore, a large part of our report is dedicated to a survey on the West German structure.

Information in this report has been collected in four ways:

- by numerous personal discussions with ministries, agencies, and organizations in Bonn, Cologne (Köln), Munich (München), and West Berlin, followed up by correspondence and telephone calls;
- by evaluating books, journals, newspapers, and other printed materials;
- by a short visit in June and a four-week travel in October 1991 to all new länder, including numerous discussions and the collection of printed material; and
- by reviewing reports made by American scientists about their own visits. This includes some provided by the American Embassy in Bonn and the European representative of the National Science Foundation in Paris.

The information collected has been used without critical comment. Personal opinions, when given, are recognizable as such. Under the present, rapidly changing, circumstances, completeness is a futile effort; additions are being considered.

The Library of Congress in Washington, DC, is collecting material on German research and makes it available to U.S. scientists looking for interaction. Also, much information is already stored in various data banks, as noted in the reports.

RESEARCH IN GERMANY

General History

Wilhelm von Humboldt (brother of Alexander) defined the German university as the place where research and teaching were given equal standing. At roughly the same time, between 1805 and 1809, Thomas Jefferson encouraged Joel Barlow to design a national university in America, offering both "research and instruction," combining the advancement of knowledge with the "dissemination of its rudiments" [from "The State of Academic Science and Engineering," National Science Foundation, 1989, p. 29]. Both Humboldt's and Jefferson's concepts were based on the ideas of the Enlightenment and on their own ideas on personal freedom. These concepts are in contradiction to the policy of dictatorships. Educating young men in independent thinking (which is the basis and the medium of scientific research) did not necessarily sit well with an autocratic government. In our own century we can observe how totalitarian governments (e.g., more or less all Warsaw Pact countries) have destroyed the unity between teaching and research by taking most of the scientific research out of the universities and placing it in special institutes. These institutes then employed individuals of a somewhat greater age who, after having finished university and obtained degrees (also supposedly being less radical than students), found themselves under the institutionalized supervision of directors.

Earlier, independent research had been a requirement for appointment as a professor at a German university. Research had also been exclusively pursued in a small number of elite German Academies, without any teaching requirement.

At the beginning of the 20th century, additional weight was given to the role of research with the founding of the Kaiser-Wilhelm-Gesellschaft zur Förderung der Wissenschaften (Emperor Wilhelm

Society for the Promotion of Science) in 1911 (Adolf von Harnack was its first president). After 1945, the Society was continued as the Max-Planck-Gesellschaft zur Förderung der Wissenschaften (MPG). Here, research programs are carried out, paid for by the government with no teaching requirements, although most of the senior scientists at the various institutes of the MPG also did (and do) some teaching at a nearby university. The position of Director at an MPG Institute is very prestigious; specific research that is pursued depends (within a broad frame) strongly on the Director's perceived interests, potentially changing when the Director changes.

The first World War and its ensuing economic crisis threatened to thwart the progress of science. In 1920, measures for its rescue resulted in the founding of the Notgemeinschaft deutscher Wissenschaft (translated as the Emergency Society for German Sciences, with the addition: a university association for the support of sciences in the general poverty after 1918). It was later renamed the Deutsche Forschungs-Gemeinschaft (DFG). It is comparable to the U.S. National Science Foundation.

Both these measures, the founding of the Kaiser-Wilhelm Gesellschaft and later of the Notgemeinschaft, were important—not only because these institutions were naturally inclined to look at scientific research as something separate from teaching, but also because they extended the area of action to the whole Deutsches Reich (German empire). This addition of a nationwide research establishment was the beginning of a novel development. After the founding of the Reich in 1871, universities (and essentially, the core of all cultural activity) had remained a prerogative of the länder; they continue so to this day.

After World War II, the DFG and the MPG with its institutes were given new life. The MPG was not particularly interested in applied research and development, but the necessities of industry and commerce required such activities. The Fraunhofer Society for Applied Research (Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung—FhG) was founded, with institutes in all German länder. In the first decades following WWII, other networks of research institutes were founded or developed out of already existing individual institutes. The German Weather Service does research on meteorology and atmospheric sciences in its various Meteorologische Observatorien. Some institutions expanded their scientific domains and acquired extensive facilities. This created common problems for all of them, thus the Arbeitsgemeinschaft für Großforschungs-Einrichtungen (Working Group for Large Research Establishments, or Working Group of Establishments for Large Research Tasks; both meanings are expressed in the German name) came into being. [This is also translated as National Research Laboratories or National Research Centers.]

Defense research is a special interest of the Research Society for Applied Natural Sciences (Forschungs-Gesellschaft für Angewandte Naturwissenschaften—FGAN), which has several institutes in various länder. This host of organizations was, however, not sufficient. Therefore, the federal government together with governments of individual länder established a number of institutes (47 in the old Republic, before reunification) under the name Institutes of the Blue List. Some ministries of the federal government and länder governments maintain their own research institutes and laboratories.

Industries need their own research facilities. These first appeared in the 19th century and have proliferated since. The well-known Battelle Institute has a branch institute in Frankfurt (Main), among others. There are a large number of smaller private institutions, and many organizations have research institutes and laboratories for their own needs.

Funding for these research networks comes from a variety of sources (the federal government, the governments of the länder, industry, and foundations). Some of these foundations (such as the Stifterverband für die Deutsche Wissenschaft and the Volkswagenstiftung) were founded exclusively to support research. On the federal level, several ministries support research; the Wissenschaftsrat (Science Council) advises both federal and länder governments on scientific issues, programs, and plans. Each of the länder has its own ministry of science, research, etc. To provide a forum for discussion on topics of interest to all länder, the ministers of these ministries formed the Kultusministerkonferenz with an office in Bonn.

Details of the German research structure and its changes from year to year are provided in some

English-language publications of the cognizant ministries or organizations; these are listed in our Report, all Parts. The following publications were prepared for English-speaking re? 'ers; they do not yet include the situation in the new länder:

- Valentin von Massow, *Organisation and Promotion of Science in the Federal Republic of Germany*, 2nd edition (Inter Nationes, Bonn, 1986).
- Frieder Meyer-Krahmer, *Science and Technology in the Federal Republic of Germany* (Longman Group U.K. Ltd, Harlow, Essex, 1990) (12th volume in series: Longman Guide to World Science and Technology) [this publication is referred to several times in the present text].
- *FRG, A Directory for Teachers and Students*, published by the Kultur-Referat of the German Embassy in Washington 1989, 31 pp. Provides addresses and brief descriptions of agencies and organizations in the U.S. and in Germany. It is available from the German Information Center, 950 Third Avenue, New York, NY 10002, Telephone: (212) 888-9840.
- Rolf R. Mueller, *The German Connection, A Compendium for Americans Planning to Study, Train or Work in the Federal Republic of Germany* (University of Missouri, St. Louis, 1988), 170 pp. A very recent addition, fully including the new länder, in German and in English, is offered in CD-ROM format by the Raabe Verlag in Stuttgart.

Additional publications are listed in our Report, Part A.

German Reunification and its Consequences for Research

For research emerging from the former GDR, the attachment of its territory to the Federal Republic of Germany meant drastic changes. The process can only be understood when seen in the greater political context:

The German reunification of 3 October 1990 was a political act expressed in the Grundgesetz (Basic Law, essenti.. ly the Constitution) of the FRG. It expressly allows other states to "join." The first step in that direction was taken by the Bezirke, districts of about county-size, into which the communist regime had divided the GDR (abolishing the traditional länder or states). After the "silent revolution" of 1989/1990, the traditional länder were re-established. Then, each of them declared that it wanted to join the Federal Republic. The Government of the Federal Republic officially accepted these declarations on 3 October 1990. From that point on, all laws of the Federal Republic, its institutions and agencies, automatically applied to the five new länder, unless individually and expressly modified. At the same time, the old city of Berlin was re-established and released from the control of the Four Allied Powers (under which it had been since 1945). It reassumed the borders it had prior to 1945, swallowing East Berlin, which had acted as the capital of the GDR. West Berlin institutions automatically expanded their responsibility over the new area.

As a result, the Federal Republic became financially responsible for the newcomers. It had to reach into its own pockets; the assets of the former East Germany were too small by far to allow financing even the most urgent needs in that territory. With this extension, the power to give orders also expanded. There is a German slogan: "Wer zahlt, schafft an" or "He who pays, also calls the shots." This became a fact of life for the research establishments of the former GDR. Although research in the new länder has had to pass close scrutiny, nothing similar had been done with their West German counterparts. It had not been deemed necessary and financially would also have been hardly feasible. According to present plans, only one scientific field will undergo a similar investigation: environmental research institutes in all of the FRG will be examined in the near future.

The structure of West German research has been extended to provide the skeleton for the reformation of East German research. Therefore, a description of East German research must include information about the West German structure. Fortunately, there is enough material available, both in German and in English. However, it is important to realize that the process of extension into the East was not a linear expansion. The Germans decided to refrain from simply carrying

over their own system. Instead, they chose a more complicated way. They were taking advantage of the occasion to use what they had learned from their own development after 1945, and to consider new concepts that were rising to the surface. They set out to build a new "research landscape" around proven structures and administrative forms, emphasizing continuing as well as newly perceived research needs. This was a difficult task, and it has been frankly admitted that errors have been made. Hardships were unavoidable and often hard to bear. For our present interest, we conclude from all this that the development is still in flux, worthwhile to observe.

There is one more point to be considered.

In the former Eastern Bloc, institutes of scientific research were often overstaffed; this situation also applied in the former GDR. Furthermore, some of the areas of research maintained by the former East German academies turned out to be of less interest after reunification because these areas were already adequately covered by existing West German institutes. As a consequence, thousands of scientists of the five new länder and East Berlin have been laid off. However, this does not reflect on the scientific quality of their work; rather, it is often a consequence of the fact that their special expertise was no longer required in the new structure. During our October 1991 visit to their institutes, we found a strong concern about the fate of these laid-off colleagues. Many attempts are being made to help them. Some are supported, at least for a while, with soft money; some others will be supported for at least 18, to as long as, maybe 36, months by special funds set up by the Federal Government. Still, many are not adequately covered. These people are frightened for their future, and many of them are already in extremely difficult circumstances. This is especially difficult; they had grown up with a false sense of security, in a society where everyone considered themselves practically an employee of the government from the moment they entered school. For them it is hard to realize now that it is exactly these unrealisti- 1 counterproductive conditions that had led to ruin of their society. Such an analysis cannot e expected from the average citizen so soon after the old system has disappeared.

Our Report, Parts A, B, and C, provides information about some of the results of this process—in general and, in some cases, as reflected in individual institutions. A recent discussion of the research situation in East Germany is found in "The Revival of Faculty and Research in the New Länder of Germany," by Eberhard Hofmann [*Professional Scholar* **1**(2), 5 (1992) and **1**(3), 4 (1992)].

AGENCIES AND ORGANIZATIONS THAT SUPPORT SCIENTIFIC RESEARCH

Even today, the principle of unity of teaching and research is the foundation for scientific research in West Germany. As indicated above, necessities of the times have produced a variety of exceptions. Nevertheless, representatives of both teaching and research continue to agree on this principle. They favor building bridges between research and teaching whenever possible. For example, advice given by the Science Council to federal and länder governments is on both teaching and research. Around this generally accepted basic principle, a network of research institutions and research-sponsoring agencies and organizations has been created.

Education, indeed many if not most cultural matters, remains the responsibility of the länder (as it has been since the founding of the modern German Empire in 1871). The federal government is careful not to violate this principle. It is not impossible for an exception to occur, but it is extremely rare! Teaching has remained entirely the responsibility of the länder; money for research often comes from federal finances. One obvious reason is that the federal government is richer than any land government. Another reason is that the cultural differences from land to land have a stronger impact on education and teaching than on research. All this is not carried to the extreme: the existence of a Federal Ministry for Education and Science (Bildung und Wissenschaft) seems to blur the distinction. The gap between the federal and the länder levels in the FRG bridge in three ways:

- the ministries for education, science, etc., in the länder have established a joint representation for discussing of mutual interests among themselves and with the federal government;

- there is a commission for education, science, etc., in which both the länder and the federal governments are members;
- some research institutes are jointly financed by both the federal and one or more land governments, on a fixed-percentage basis (GFE and BLE).

In the nongovernmental realm, research is promoted by a variety of organizations. Some of these are legally private, even if they receive all (or most) of their funding from the governments, federal and/or länder. In addition, private or industrial funding sources exist, they vary widely.

Research institutions can be classified. For this report, we consider the following groups to be especially interesting:

- GroßForschungsEinrichtungen (GFE) — Large Research Establishments, also called National Research Centers (or Laboratories)
- Blaue-Liste Institute (BLE) — Institutes of the "Blue List"
- Max-Planck-Gesellschaft (MPG) -- Max-Planck Society
- Fraunhofer Gesellschaft (FhG) — Fraunhofer Society
- Forschungs-Gesellschaft für Angewandte Naturwissenschaften (FGAN) — Research Society for Applied Sciences
- Ressort-Forschungs-Institute — Research Institutes under individual ministries of the federal or länder governments; especially the Deutscher Wetterdienst (German Weather Service) under the Federal Ministry for Transport
- Private or industry institutes
- Research institutes of the universities.

Main sources of research financing are:

- Bundesministerium für Forschung und Technologie (BMFT) — Federal Ministry of Research and Technology (FMRT)
- Land Ministries for science and research (have different names in the various länder)
- Other federal or länder ministries
- Deutsche Forschungs-Gemeinschaft (DFG)—German Research Society (German equivalent of the NSF)
- Volkswagen-Stiftung — Volkswagen Foundation
- Stifterverband für die Deutsche Wissenschaft — Donor Association of German Science
- Other foundations
- Industry (more than half of research expenses are funded by industry)
- Other private sources
- International sources, e.g., the European Community, North Atlantic Treaty Organization (NATO).

Some of the Foundations do not directly support research (for example, do not finance institutes) but support individual researchers.

Joint financing is frequent. For example, the Fraunhofer Institutes are expected to obtain more than half of their budget from nongovernment sources, e.g. industry or foreign contracts. Blue List Institutes (BLE) get half of their funding from the federal government; the other half comes from the land in which they are located. The Large Research Facilities (GFE) get 90 percent from the federal government and 10 percent from the respective land. In many if not most cases, a project that is supported by the DFG will receive additional funding from other sources.

In this connection, a number of agencies that provide different kinds of support should be mentioned:

- The Wissenschaftsrat (Science Council) in Cologne (Köln) advises the federal and länder governments on matters of science and research, including universities and colleges.
- The organization "KAI" in Berlin (which changed its affiliation on 1 January 1992, but not its name) implements or helps to implement the recommendations of the Wissenschaftsrat on reforming the former research institutes under the GDR Academy of Science.
- The Kultusminister-Konferenz (KMK) maintains an office in Bonn, representing all the science, etc. ministers of the 16 länder.

- The Rektoren-Konferenz (HRK) has an office in Bonn that represents the Rektoren (roughly equivalent to presidents) of all the universities in the Federal Republic.
- The Bund-Länder Kommission für Bildungsplanung (BLK) has an office in Bonn in which the ministries for science and other cultural matters and their officials at the federal and the länder levels meet to discuss, advise, and decide on topics of common interest.

More details on the institutes, financial resources and supporting agencies and organizations listed above are provided below.

Federal Agencies

Wissenschaftsrat (Science Council) and Implementation of Its Recommendations

The Wissenschaftsrat is a high-level advisory body formed in 1975 by an agreement between the federal and the 11 länder governments to advise them and other bodies on matters of science. It is sometimes compared to the U.S. National Research Council. This comparison is misleading because direct governmental action in scientific and education matters is so much stronger in the FRG than in the U.S. (e.g., nearly all German universities are state universities under a land government); therefore, the Wissenschaftsrat is asked for recommendations much more frequently than is the National Research Council. Its name is often translated as Science Council; this is a correct translation but it can cause some confusion, especially in the FRG, because of the unique position of this body. For this reason, we prefer to use the German name in this report.

Of the 32 members of the Scientific Commission of the Wissenschaftsrat, the president of the Federal Republic appoints 24 senior scientists and 8 "persons of public life". The 32 votes of the Administrative Commission are composed by six official representatives of the federal government (who together have 16 votes) plus 16 official representatives of the länder governments who have one vote each. Its president is Prof. Dieter Simon, the president of the Max-Planck Institut für Rechtsgeschichte in Frankfurt (Main); he has recently been reappointed for another period of three years. Its Secretary-General is Ministerialdirektor Dr. iur. Winfried Benz.

The Wissenschaftsrat issues Recommendations, which generally are implemented. The quality of these recommendations has made these very prestigious. (The evaluation of a proposal to found a new university is a typical activity.) After reunification, the Wissenschaftsrat was tasked with evaluating the science situation in the former GDR. There were two areas of special urgency for this task:

- The fate of the more than 25,000 scientists employed by the former Academy of Sciences (and two smaller academies) of the GDR had to be considered. This was one reason for a careful evaluation of the approximately 80 Institutes of the Academies; on the basis of these evaluations, the government had to decide about continued employment of the scientists. This action had been prepared in advance but actually began immediately after reunification (3 October 1990). The deadline was 15 July 1991 and was met. As a general result, most scientists retained their employment until 31 December 1991. Many of those who could not be employed after 1 January 1992 are being supported by the federal government (with other means) for a period of at least 18 months (some think that this will be expanded to 36 months, i.e., until the end of 1994).
- Certain domains of university education needed to be changed almost immediately. These were, first, departments strongly influenced or, more accurately, governed by Marxist ideology (such as jurisprudence, history, social sciences); and, second, engineering and business management because of the impending changes in industry and commerce. Next came medicine, to be evaluated in the fall of 1991. The situation of the natural sciences and the other humanities taught at the universities presented a less urgent task. It was agreed that a more local evaluation by the länder governments should proceed before the Wissenschaftsrat expressed its opinion.

This process was implemented in the summer and fall of 1992.

The evaluation of the former Institutes of the Academy of Sciences began with reports written by the institutes to be evaluated. These were passed on to a panel of senior German scientists of the particular scientific domain, as well as to scientists from other countries. These panels then visited the institute in question and submitted their reports to the Wissenschaftsrat. Finally, the institute in question itself got the report and was informed of the results of the evaluation.

It is important to realize that this evaluation did not simply represent a judgment on the quality and necessity of the work done at these institutes. Such a judgement might then be followed by recommendations to either continue or to terminate the work. Instead, a much more difficult, but also more promising, way was chosen. The whole edifice of research—the Germans call it the "Research Landscape"—was restructured. Individual tasks of individual institutes were extended, reduced, or cancelled; new ones were proposed. Often, departments of an institute were taken out and incorporated with another institute; new institutes were proposed.

Existing ties between institutes and universities were modified, mostly made stronger, and numerous new ties were established. Many institutes located near universities have become connected with the universities in a special way (similar to the relationship between the Johns Hopkins University and the related Applied Physics Laboratory). In particular, senior scientists of the institute are often appointed to become also professors at the university. Vice versa, university students are being admitted to the institute for part of their experimental work and education. Such ties are usually described by the particular form of the name of the institute. While an institute within a university (i.e., part of it, under its administration) will have the name "Institute for... of the ... University", an institute of this type will be called "Institute for.....at the......University". The new class name for this type of institutes is "An-Institut", translated as "At-Institute".

The recommendations of the Wissenschaftsrat also often included suggestions about a kind of contractual relationship between various institutes ("Verbund"). This term is familiar to Germans; it designates the connection between various carriers of urban traffic in the same town, each remaining independent but agreeing to some joint interaction with the others to benefit the consumer. These Verbunds can be of interest to an American researcher entering into a discussion with an East German institute because this arrangement may broaden the scope of joint efforts.

Obviously, rearrangement and new creation on such a scale was a historically unique event. It presented an extremely exciting but also very difficult task. The difficulty was increased by the urgency of arriving at immediate recommendations.

Most of the senior scientists evaluating the institutes were above the risk of looking at their own tasks from a competitive perspective. There certainly were some exceptions, and some errors did occur. But the overall result is generally considered to be correct and successful in a positive sense. On the other hand, some researchers in the East may misinterpret some of the results because they are not yet be familiar with all the necessities and procedures of a free society.

Reports by the Wissenschaftsrat are discussed in our Report, Part A.

KAI

Recommendations made by the Wissenschaftsrat were considered by the appropriate political bodies, and basic decisions were made. After these decisions, a body was needed to implement them. The Ministry of Research and Technology established such a body in the former headquarters of the GDR Academy of Sciences in the Otto Nuschke Straße 22/23"(now renamed Jäger Straße again). This body was named:

> Koordinierungs- und Abwicklungsstelle für die Institute und Einrichtungen der ehemaligen Akademie der Wissenschaften der DDR—(Coordination and De-Establishment Agency for the Institutes and Institutions of the former Academy of Sciences of the GDR), abbreviated as KAI-AdW.

On 1 January 1992, this agency was reestablished as an association named:

Koordinierungs- and Aufbau-Initiative für die Forschung in den Ländern Berlin, Brandenburg, Mecklenburg-Vorpommern. Sachsen, Sachsen-Anhalt und Thüringen" (Coordination and Establishment Initiative for Research in the Länder Berlin, Brandenburg, etc.) abbreviated as KAI-eV.

The Director of KAI was Mr. Grübel; Dr. Rabenhorst was in charge of international relations.

KAI should not be confused with another German institution charged with transitions after the reunification: the Treuhand Anstalt (president: Frau Birgit Breuel), which is tasked with privatizing state-owned industries in the former GDR. This includes selling about 10,000 companies, many having their own research laboratories. By the end of 1991, about 4,000 companies had been sold. This agency is also looking for American buyers.

Federal Ministry of Research and Technology (FMRT) — Bundesministerium für Forschung und Technology (BMFT)

The FMRT is the agency of the government responsible for scientific research. This fact is expressed, for example, by the Federal Report on Research (Bundesbericht Forschung) and the supporting publications, listed and briefly described in our Report, Part A. It is a comprehensive and informative source for nearly all aspects of research in the FRG, including its philosophy and realization. Since reunification, the FMRT has been the top executive government agency overseeing the creation of the new research landscape in the five new länder and East Berlin. This additional assignment has increased its responsibilities 15 to 30 percent, not counting the immediate efforts caused by the transition process itself.

The primary aims of the FMRT are (quoted from Meyer-Krahmer, p. 79):

- "The broadening and extending of scientific knowledge, thus it finances large parts of basic research as an important requirement for scientific and technological advance and contribution to cultural development;
- the promotion of research and development in the fields of environment, health and labor, with the purpose of improving living conditions;
- the direct and indirect support of entrepreneurs willing to take research and development initiatives, thus increasing the economic performance and competitiveness, which is crucial for the German economy depending on exports."

In both 1987 and 1988 (i.e., before reunification), roughly the following amounts [in deutschmark (DM) million] were spent (remember that the translation of the German terms into English is by necessity imprecise):

Basic Research — 2,800
Government Long-Term Projects — 1,400
Research for Future Needs) — 900
Market-Oriented Technology — 3,000
Infrastructure — 430.

In the same years, the number of institutes supported by the FMRT in the various länder was:

Nordrhein-Westfalen — 1,500
Baden-Württemberg — 1,400
Bayern (Bavaria) — 1,100
Foreign Countries — 1,000;

the other 8 länder of the (former) Republic each had less than about 500.

The following research fields are covered, with the approximate amounts (in DM million) spent on each of them:

- Special areas of basic research, in particular, large equipment in the National Research Centers — 950
- Ocean and Polar Sciences and Technology — 200
- Space Research and Technology — 1,100
- Energy Research and Technology — 1,370
- Environmental, Climatology, and Safety Research — 380
- Research and Development for Health — 300
- Information Technology, including Manufacturing Technology — 900

- Biotechnology — 230
- Material Research and Technologies — 340
- Aeronautics and Supersonic Technology — 175
- Research and Technology for Surface Traffic — 220
- Geosciences and Raw Material Provision — 60
- Other Activities — 550.

Their catalog lists about 750 research subgroups.

Federal Ministry for Science and Education (Bundesministerium für Wissenschaft und Bildung, BMBW)

(quoted from Meyer-Krahmer, p. 81):

"Since the beginning of 1973, the Federal Ministry of Education and Science (Bundesministerium für Bildung und Wissenschaft, BMBW) has had full responsibility at the federal level—from pre-school to university, including vocational education/training, educational assistance, further education as well as the promotion of science and research at universities (except for the responsibilities of the other ministries concerning vocational training)...The staff of the BMBW at the end of 1988 amounted to 390 members working in four divisions; the 1988 budget was approximately DM 3.5 billion. They planned to spend DM 1.2 billion on R&T in 1988 (compared to 7.6 by the FMRT)."

Background information is provided in the small annual trilingual publication of the BMBW, *Zahlenbarometer; Numerical Barometer; Baromètre numérique*.

Federal Ministry of Defense (FMod) (Bundesministerium der Verteidigung)

As in many other countries, the German Ministry of Defense maintains its own research and technology program. Because financial support for defense research and technology in the FRG is much smaller than in the U.S., German efforts are focused on selected areas. (According to a German estimate received in summer 1992, the U.S. spends about 15 times as much as the FRG on military research and technology.) Cooperation with foreign, allied, efforts in scientific research and technological development is supported to use resources more efficiently and to strengthen ties between partners. Basic research is conducted and is also included in international cooperation if it is within a defined focus (e.g., shallow-water oceanography as needed for specific technological developments, computer structures, and associated microelectronics are among such areas). Within FMoD, the Department Rü T (Rüstung, Technologie = Armament, Technology) is in charge of research and technology.

Within the German Defense research and technology establishment, we find the

Forschungsanstalt der Bundeswehr für Wasserschall und Geophysik (FWG) — Research Institute of the Federal Armed Forces for Underwater Acoustics and Geophysics, in Kiel.

Basic research (in the American definition of this term) for the FMoD is also carried out by laboratories in various locations in the FRG within the

Forschungs-Gesellschaft für Angewandte Naturwissenschaften (FGAN) — Research Institution for Applied Sciences; and by

institutes and laboratories of the Bundeswehr-Hochschulen (Defense Universities) in Munich (München) and Hamburg.

The embassies of the FRG in Washington, London, Paris, and Rome have Counselors for Defense Research and Engineering.

Research Institutes of Government Ministries (Ressort-Forschungs-Einrichtungen)

In addition to the Wissenschaftsrat and the ministries listed above, other federal ministries are also active in scientific research and have their own research facilities (called, in German, Ressort-Forschungs-Einrichtungen). As taken from Meyer-Krahmer, p. 191 ff (valid only for the old 11 länder, before reunification), the following federal ministries maintain their own research institutes,

agencies, or organizations, several of which are located outside of the FRG:

- Federal Ministry for Labor and Social Affairs (2)
- Federal Ministry for Post and Telecommunications (2)
- Federal Ministry for Regional Planning, Building and Urban Development (1)
- Federal Ministry for Research and Technology (FMRT, FMFT) (7)
- Federal Ministry for Youth, Family, Women and Health (3)
- Federal Ministry of Defense (1) [Meyer-Krahmer lists 2, but only one is really an institute under the FMoD, the other is an organization funded by FMoD]
- Federal Ministry of Economic Cooperation (1)
- Federal Ministry of Economics (2)
- Federal Ministry for Education and Science (1)
- Federal Ministry of Food, Agriculture and Forestry (13)
- Federal Ministry of The Environment, Nature Protection, and Reactor Safety (2)
- Federal Ministry of the Interior (4) [The mission of the Federal Ministry of the Interior is different from the mission of the U.S. Department of the Interior, but the four institutes deal with topics that could also be of interest to the U.S. Department of the Interior]
- Federal Ministry of Transport (5) [This ministry is also responsible for the German Weather Service, which is counted in this list as one unit but in fact has several research institutes (meteorological observatories)]
- Foreign Office (1).

For the five new länder, the recommendations of the Wissenschaftsrat (Allgemeiner Teil) list 18 Ressort-Forschungs-institutions under federal ministries, of which about 10 concentrate on agriculture and forestry. Soon after reunification, the German Weather Service (under the Federal Ministry for Transport) established its largest research institute—the traditional and world-renowned Meteorological Observatory in Potsdam. Other institutions were recommended to become direct parts of existing (i.e., West German) institutions under the ministries.

Common Agencies of Länder and Federal Governments

- *Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland, KMK* (Standing Conference of the Ministers for Education, Sciences, Arts of the FRG Länder)

This is a special committee, established with an office in Bonn; it serves for discussions between these ministries of the various länder. It can make binding decisions by unanimous vote.

- *Konferenz der Rektoren und Präsidenten der Hochschulen in der Bundesrepublik Deutschland (HochschulRektorenKonferenz, HRK)* (Standing Conference of the Rectors and Presidents of the Universities and Colleges in the FRG).

The former name of this conference was Westdeutsche Rektorenkonferenz, WRK. Under this name, annual reports were issued (Arbeitsbericht) and from time to time collections of statistical data on educational issues in Germany (Arbeitsmaterialien, Zusammenstellung bildungspolitischer Daten) were published. In February 1992, this conference had 222 members.

- *Bundes-Länder Kommission für Bildungsplanung* (Commision of the Federal Republic and its Länder for Planning in General Education)

In addition to routine obligations, this Commission now has the additional task of combining the efforts of the federal government and the länder governments in restructuring the "university landscape" and the nonuniversity research, based on recommendations of the Wissenschaftsrat. Since the so-called Institutes of the Blue List are characterized by the fact that the federal government and the cognizant land government each pay 50 percent of their costs, these institutes are a natural area of effort for this Commission. The Commission has

published almost 70 public reports on Education Planning, Innovations in Education, and Promotion of Research. In addition, annual reports (in 1990, 63 pages long) provide statistics, including finances and names of persons and institutions.

Länder Agencies

Remarks on the Research Situation in the Länder

The traditional German name for länder ministries responsible for cultural affairs, etc., was Kultus—sometimes also Kult-Ministry. In most cases, they were responsible for all forms of education in that land, including universities as well as adult "after-hours" education, for science, research, art, for museums, theaters, and for religious matters. More recently, some of these ministries have modified their name or split into several separate units.

In Part A of our Report, we note only the länder ministries that are principally responsible for scientific research in the five new länder and East Berlin. It is, however, important to know that other länder ministries also may and do conduct research, establishing their own institutions.

A detailed survey on research in the länder is contained in the *Bundesbericht Forschung*, edited all four years by the Federal Ministry for Research and Technology; however, this information is not contained in its English translation. It is probably too early to describe similar efforts in the five new länder. The 1992 edition of the *Bundesbericht Forschung* will include the five new länder for the first time.

Organizations

In the following, legally independent organizations (some of them depending heavily on government funds for their operation) are listed in three groups:

- organizations maintaining research institutes and/or similar facilities, or representing the interests of such institutes and facilities;
- organizations supporting individual researchers or individual research projects, and
- academies and similar establishments.

Organizations, institutes, and government agencies predominantly working for international relations or collaboration are listed below under "American/German Exchange and Collaboration". However, most of the agencies and organizations listed here also maintain international relations and promote international collaboration.

One organization, KAI, has been described above because it had been, until 31 December 1991, a government organization and as such performed work of special interest in the scope of this report.

Part B of our Report lists all institutions of the organizations listed in here, except the industrial establishments.

Organizations Maintaining or Representing Research Institutions

Max-Planck-Gesellschaft zur Förderung der Wissenschaften (Max-Planck Society for the Promotion of Science)

This society was founded in 1911 under the name Kaiser-Wilhelm-Gesellschaft zur Förderung der Wissenschaften (Emperor Wilhelm Society for the Promotion of Science) in Berlin-Dahlem. It was different from the traditional academies of that time (which did not maintain their own dedicated research institutes) and from the universities (where no systematic teaching was involved). A strong scientific reputation was quickly established thanks to v.Harnack, its first president, and to the appointment of outstanding scientists as directors of the institutes. These directors were given the liberty to select and pursue their own scientific interests within a rather broad scope of science. An idea (attributed to v.Harnack) was to get a good scientist and to build an institute around him. The liberty to determine the objectives is still alive—so much so that when a new director for an institute is appointed, the narrower scientific covered field may change, and with it many of the co-workers. However, certain traditions will

automatically be established, and in many cases maintained.

The scientific staff of an individual institute is approximately of 100, working in several departments. More than 1000 foreigners are among the total number of scientists in the various institutes, with Americans being the largest group. More information is provided in our Report, Part B, and in the following book (in English):

> R. Gerwin and B. Holzt, *The Max-Planck-Gesellschaft and Its Institutes, Portrait of a Research Organization*, translated by R.Friese (Press and Public Relations Department, MPG, 1984) 3rd edition, 140 pp.

This book also describes the individual institutes and their departments with the scientific fields covered, the number of scientists, etc., and the names of directors.

During the annual assemblies of the MPG, a keynote speaker usually presents a very interesting description of the situation and trends in German and international basic research and its connections to the general scientific world. This speech and the other addresses of the assembly are printed verbatim in the assembly report.

As soon as the possibility of German reunification appeared, the problem of reorganizing research institutions in the GDR arose. A decision had to be made almost immediately: Should the West Germans suggest to the East German government that they organize a system of research administration and general structure similar to that of West Germany, with the intention of uniting with their West German sister organizations at a later time? Because of expected difficulties in uniting two independent organzations (and also for other reasons), it was decided not to suggest such a move. Instead, the West German organizations prepared to incorporate individual East German institutes into the existing West German structure. Preparations for this began in parallel within the organizations. The Max-Planck Society began its own preparations independently. Because not enough was known about the status of research in the GDR, a new structure was proposed: the establishment of Max-Planck Arbeitsgruppen (Working Groups) under scientists with acknowledged reputations. The plan was and is to let such a group work for about five years, financed by the Max-Planck Society, and then to decide whether they should be incorporated into universities or transformed in Max-Planck Project Groups or Institutes. In two cases it was also realized that the level of research as well as the need for the promotion of that particular type of research were high enough to permit the establishment of two Max-Planck Institutes from the very beginning.

Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung (FhG) (Fraunhofer Society for the Promotion of Applied Research)

This society, founded 1949 in Munich, is the largest institution for applied research in the FRG. It has 37 research and service institutions in nine of the eleven old länder. Its turnover runs to DM 759 million, with contract research accounting for approximately DM 585 million. Fraunhofer Institutes make the results of their research available to clients in industry and government by way of contract research projects that aim to transform results into commercial processes and marketable products. FhG has about 650 members. Its "Senate" consists of representatives from government, science, and industry. Publications are available upon request for the following "Focal Fields": Microelectronics; Information Technology; Production Automation; Production Technologies; Materials and Components; Process Engineering; Energy Technology and Construction Engineering; Environment and Health; and Studies and Technical Information Exchange. An abbreviated version of their annual report is available in English.

The FhG publishes much information material, some in English. The addresses and keynote speeches given at their Annual Assemblies are usually very interesting presentations of the situation and trends in German and international applied research and its connections to the industrial world (printed verbatim in the assembly reports).

Concept development and plans for an extension into the five new länder and East Berlin became an important concern for the FhG immediately after the new developments in East Germany became evident. An extension of a modified version of the West German FhG structure into the new länder was discussed and implemented. So

far, no new Fraunhofer-Institutes are in the East; instead nine Fraunhofer-Einrichtungen (Fraunhofer Establishments) plus ten Fraunhofer-Aussenstellen (Fraunhofer branch laboratories of existing West German institutes) were organized.

Arbeitsgemeinschaft der Groß-Forschungs-Einrichtungen, AGF (Working Community of Large Establishments for Research)

This is a common institution of the National Research Centers (or Laboratories), representing their interests, promoting the exchange of experience and information among the laboratories, acting on common tasks, and assisting in the coordination of research and development. With an annual budget of between DM 2,500 and 3,000 million (1989 to 1994) and a personnel count of nearly 10,000, the AGF represents the largest research unit in the FRG. For most of its member institutions (also called AGF-Zentren, Centers), 90 percent of the budget comes from the federal government; the remaining 10 percent is provided by the land in which the institution is located.

In the eleven old länder, AGF has 13 Centers; some of them are composed of several institutes located in more than one land. In the five new länder, 11 institutes are being established, some of them being a kind of branch of a West German National Research Center.

Arbeitsgemeinschaft Forschungseinrichtungen Blaue Liste, AG-BL (Working Community of the Research Establishments of the Blue List)

The AG-BL represents a special type of research institute. In 1975, the federal and länder governments signed an agreement on common research promotion. In it, the Groß-Forschungs-Einrichtungen and the Max-Planck and Fraunhofer institutes were confirmed but the desirability of an additional type of research institute was also acknowledged—non-university institutes. The importance and influence of these exceed the borders of the land in which they are located, and the research done here was noted as being of common government interest.

The first list of such institutes was printed in 1977 on blue paper. In 1991, there were 47 such institutes in the eleven old länder. They employed almost 5,000 people and required more than DM 500 million for their operation. At reunification, approximately 30 more such institutes were planned for the five new länder and East Berlin. In 1990/91, the need for a common representation led to the foundation of the AG-BL.

Arbeitsgemeinschaft Industrieller Forschungs-Vereinigungen 'Otto von Guericke', AiF (Cooperative Group of Associations of Establishments Doing Research for Industry and Commerce)

The AiF has as its members more than 100 associations, societies, etc., totaling more than 10,000 mostly small or medium-size independent establishments that do research for a variety of industrial and commercial areas. Research laboratories belonging to industrial or commercial companies are not included. The AiF was founded in 1954; legally it is a private, licensed, nonprofit association.

Organizations Supporting Researchers and/or Projects

This section describes two very different types of organizations. Legally, they may be quite similar because they are all private. Among them, the Deutsche ForschungsGemeinschaft is almost fully financed by governments and is also, by far, the largest organization in the FRG dedicated exclusivly to supporting individual researchers and groups (sometimes almost ad hoc groups) of researchers. The other organizations listed are financed by a large variety of mostly private (or mixed private and public) sources. Together they constitute a broad and varied spectrum of foundations (Stiftungen). Several forms of collaboration or coordination exist between them. Somebody has counted more than 5000 foundations in the FRG. We are reporting on a selection of them which, for our purposes, seemed to be the most relevant ones; admittedly a very shaky definition. All organizations listed here promote, often pointedly so, international exchange as one of their tasks or intentions.

Deutsche Forschungsgemeinschaft, DFG (German Research Association)

This association is roughly comparable to our National Science Foundation. There are certain essential differences (our impressions are noted below, under "Discussion of the Situation in the Former GDR"). The DFG describes itself as follows (January 1991):

> "The DFG is the central self-governing organization of science and the humanities in the FRG. Since the DFG was founded in 1920, its statutes have assigned it the continuing responsibility of promoting "science in all its branches". The DFG supports research projects in every discipline, especially within basic and applied research as pursued in the universities and technical academies. Particular attention goes to fostering oncoming generations of researchers."
>
> In its promotion of research, the DFG distinguishes between assisting individual projects [individual Grants Program (Normalverfahren)], and promoting cooperative activities [Priority Programs (Schwerpunktprogramme); Collaborative Research Centers (Sonderforschungsbereiche); Research Units (Forschergruppen); and Central Research Facilities (Hilfseinrichtungen der Forschung)].
>
> Within the individual Grants Program, any researcher can apply for assistance if he needs additional funds for a research project of his own choice. This assistance can be, e.g., in the form of material or equipment, personnel costs, or funds for travel or help with printing costs. The oncoming generation of researchers is fostered by, in particular, grants for training, research and travel. The Priority Programs assist cooperation by researchers—each in his own research institution—of various scientific institutions and laboratories within the framework of a common theme or field of research. During the usual duration of five years, new individual projects may be presented. The Research Unit designates a medium-term cooperation of a number of researchers who jointly pursue a research program, usually in one place. The joint research is facilitated by a concentration of the personnel and the equipment needed for scientific and technical services. Central Research Facilities (Hilfseinrichtungen der Forschung) are funded to provide technical services and equipment for particular fields of research on a national basis. The research ship *Meteor* and the Central Institute for Laboratory Animals are examples. Collaborative Research Centers involve groups of scientists who have, with the approval of their universities, combined their effortss to pursue joint research in areas in which the respective universities recognize a focal point of activity calling for long-range support. The Collaborative Research Centers aim at concentrating personnel and material facilities, planning and coordinating research within and under the supervision of the universities, and interdisciplinary cooperation.

In addition, the DFG finances and initiates measures to promote scientific libraries, equips dataprocessing centers with computers, makes available a variety of apparatus for research purposes, and reviews applications for equipping research centres with apparatus within the framework of the law for the improvement of university facilities.

On the international level, the DFG has taken over the responsibility of representing German science in international organizations. It coordinates and finances the German share in major international research programs. Moreover it supports international scientific relations through individual measures such as travel grants.

Another basic responsibility deriving from the DFG statutes is providing advice on scientific matters to parliaments and public authorities. A large number of commissions and committees of experts furnish basic scientific information for use in legislation—especially for laws involving the environment and public health.

In its legal form, the DFG is an association under civil law. Its members are universities, academies of science, research establishments of general scientific significance, the Max-Planck-Gesellschaft, the Fraunhofer-Gesellschaft, and a number of other scientific associations.

In order to fulfill its responsibilities, the DFG receives funds from the federal government and the eleven states, as well as a yearly

contribution from the Donors' Association for the Promotion of Sciences and Humanities in the FRG. In addition, the federal government makes available special-purpose grants, e.g., for congresses and conventions, for donations of books to installations abroad and for the exchange of scientists." (End of its own description).

Stifterverband für die Deutsche Wissenschaft (Donors Association for the Arts and Sciences)

This group represents a joint venture of German industry and commerce to promote the sciences. More than 160 foundations (and nearly 5000 other members) are included in its membership. A total capital of about DM 800 million produces approximately DM 60 million each year for the purposes of the association. In most cases, the foundations bear the personal name of their founder (Stifter). As to be expected, each foundation is dedicated to a special task or group of tasks. Nevertheless, the Stifterverband still has important decisions to make. It can set areas of emphasis. At the present time, one emphasis is not only on reunification of German science but also on preparation for a German role as a bridge between the sciences in West and East. The Stifterverband has financed travels to, e.g., the Gordon Conferences in the United States. In helping these and other international programs, the Stifterverband follows its clearly expressed opinion that no country and also no group of countries can pursue science in isolation. In 1992, the Stifterverband and the Ford Foundation supported a program to bring East German postdoctoral students to the U.S. for one term to study social, political, or contemporary historical sciences at an American university; this was organized by the American Institute for Contemporary German Studies.

Volkswagen-Stiftung (Volkswagen Foundation)

After World War II, the Volkswagen company was converted to a joint stock company by a treaty between the federal government and the land of Lower Saxony (Niedersachsen). Sixty percent of the share capital was placed in private hands. The Volkswagen Foundation was established in 1961 by endowing it with the proceeds from the sale of shares. This foundation is a nonprofit foundation, chartered under private law. At present it has a capital of DM 2,800 million. The foundation's aim is to promote science and technology in research and university teaching. It is free to support any area or field of science including the humanities; in principle however it has limited its funding to varying program areas. Support can be given for any type of expenditure encountered in research and university teaching. It is addressed to institutions, not to individuals. In principle, applications received from abroad are treated like German applications. They should also be related to a particular program area and should describe a defined cooperation with German scholars or research institutions. Applications by German institutions may include the expense of cooperating foreign partners. Applications from abroad may be submitted to the Volkswagen Foundation at any time. International cooperation, to mention just a few examples, may take the forms of joint studies carried out by German and foreign scientists; of tackling identical problems simultaneously but by different methods; of cooperation in mutually controlled and complementary studies; of mutual exchange of scientists or scholarship holders; or of guest professorships.

The *Robert Bosch Foundation* was established by the Bosch family between 1962 and 1964. It owns approximately 90 percent of Robert Bosch GmbH, a worldwide enterprize that manufactures electrical, electronic, hydraulic, and pneumatic equipment for the automotive industry. The Robert Bosch Foundation uses its share of company profits solely for charitable purposes. Its goals are furthering International Understanding; Public Health and Welfare; and Education, Art, Culture and Science. Progress toward these goals is made through a growing number of international study and internship programs. The Fellowship Program for Young Americans is one of these. Fellows receive internships in such key German institutions as the federal government, the federal parliament, and the headquarters of private corporations. This program is of interest to Americans with backgrounds in business administration, economics, public affairs, political science, law, journalism, or mass communication. In addition, the foundation

supports special projects that promise new ideas and developments or address urgent needs of our time.

The *Carl Duisberg Society* (Carl Duisberg Gesellschaft eV.) has been active for many years in providing young Americans (usually businessmen, engineers, and agriculturists) with study experiences in the FRG, including complete professional training for people already in leading positions. It administers a large number of diversified programs; these include:

- Congress-Bundestag Youth Exchange
- Career Training for Americans and Europeans in a foreign country
- The Robert-Bosch Fellowships
- Internships for Americans in the FRG and for Germans in America
- Workforce Solutions for America's Future: adapt European experiences in vocational training to the United States
- Internships for young German professionals in U.S. companies
- Study tours for U.S. business and educational groups to the FRG and other European countries
- UNIDO Fellowship: managerial and technical professionals from developing countries to the U.S.
- Regional Programs, e.g., Berlin-Indianapolis Police Exchange, Corporate fellowships, from 3 to 18 months advanced training in the U.S., supported by corporate sponsors
- Customized German language training.

The *Alfried-Krupp-von-Bohlen-und-Halbach-Stiftung* was established by the last personal owner of the famous Krupp Corporation, Alfried-Krupp von Bohlen und Halbach (1907-1967), in his will; it was officially founded in 1968. In its first twenty years, the foundation spent DM 116 million for science, DM 68 million for education, DM 125 million for health care systems, DM 14 million for supporting sports, and DM 37 million for general cultural purposes. Its many programs, varying broadly in their purposes, reach out to many foreign countries in all continents; a survey lists about 50 programs. Of special interest for Americans are:

- Stipends for graduates in energy research (about DM 2,000 per month for 2 years)
- Award for Energy Research, DM 500,000, international
- Support for the Salk Institute, San Diego
- Institute for East-West Securities, New York
- Krupp-Foundation Internship Program in the FRG for Stanford University Students
- Harvard University "Krupp Foundation Professor in European Studies"
- *John J. McCloy Fund of the American* Council on the FRG for stipends to young Americans and young Germans.

Not all of these programs are active at present.

The *Fritz Thyssen Stiftung* was founded by Mrs. Amélie Thyssen in 1959 to promote science at universities and research institutions, especially in Germany. The foundation implements this objective by financing well-defined and reasonably limited research projects. The international stipend and exchange programs involve the Princeton *Institute for Advanced Studies;* a lecture series on American politics, economy, society, and history; and lecture and discussion programs at American universities and others, predominantly in the humanities and social sciences.

The *Studienstiftung des Deutschen Volkes* (Scholarship Foundation of the German People) is well known in the FRG for its broad support of selected students throughout their university years. Although directed only to Germans, it will support their stipends when they have a good reason to go to a foreign country for graduate and doctorate work.

Academies

From the viewpoint of our present discussion, probably the most interesting scientific academy in the five new länder is the Deutsche Akademie der Naturforscher Leopoldina, in Halle in the new land Sachsen-Anhalt. With the permission of the Science Section of the U.S. Embassy in Bonn, the following is an excerpt from a report on the Leopoldina that was submitted to the U.S. State Department on 26 July 1991:

From: American Embassy Bonn
Subj: THE LEOPOLDINA: SURVIVAL OF A UNIQUE SCIENTIFIC ACADEMY IN EASTERN GERMANY

1. Summary: The Leopoldina Academy of Science in Halle is one of the few East German science institutions that has emerged from the GDR period with its reputation intact. With its distinguished international membership, the Leopoldina served the GDR regime as a window on the West. At the same time it protected dissidents within the East German science community. While its future mission within the unified Germany is now being debated, this ancient academy has supporters in Bonn. Its President, Dr. Parthier, has been nominated to join the German Science Council. He will also participate in the September 9-11 U.S./German Science Conference in Berlin. End Summary.

2. As the former GDR research establishment is being dismantled and reconstructed pursuant to directives from Bonn, an ancient scientific academy with its headquarters in a quiet back street of Halle has emerged with its reputation enhanced by its role in harboring dissidents within the East German science community. The Leopoldina traces its roots back to the 17th century, and its name to a charter issued by the Holy Roman Emperor, Leopold I, in 1687. It has viewed itself as an international scientific academy comprising German-speaking scientists in the fields of medicine and the natural sciences.

3. The Academy was founded in Schweinfurt, and thereafter moved its seat and its library to different university towns within Germany, depending on the residence of the Academy President. It was located in Bonn in the years 1819-30. By the late 19th century, the Academy library had grown too large to be moved, and since 1878 the Academy has remained in Halle, where it occupies a Library/Administrative building and a relatively modern conference center near the library of the Martin Luther University. Its membership is centered primarily in the FRG, Austria, and Switzerland, but it includes a significant number of distinguished international scholars, including Nobel prize winners. The Academy's 1989 membership roll included 89 American scientists, 45 Soviet scientists, and modest representation from other West and East European countries.

4. The Leopoldina's reputation and distinguished international membership helped shield it from political pressure under both the Nazi and GDR regimes. The low point occurred in 1938 when it was forced to take Jewish scientists off its membership rolls. According to Bonn observers, the Academy was not completely free from political influence under the GDR, but it was able to host international conferences and to acquire scientific literature freely, and its officers were allowed to travel. This freedom was due in part to the reputation and efforts of the outstanding scientists who have headed the Academy, the physicist Heinz Bethge and plant biologist Heinz Parthier. At the same time, the Academy provided prestige and served as a window on the West for the GDR science establishment. This symbiotic relationship with the GDR regime must have been an uneasy one for the Academy, and it took steps to insure its privileged position by always filling the first Vice President position with an Academy member from Munich. Academy representatives signaled GDR authorities that at the first sign of interference, the Academy would close its doors in Halle and reestablish in Munich. Thus insulated, the Academy succeeded in giving a measure of protection to dissidents within the GDR science community. It provided a scholarly niche for inter-German exchanges, and its conference activities offered a venue for both East Germans and East European scientists to meet Western counterparts.

5. With the loss of its special identity within the GDR, Leopoldina is trying to determine what it should now do. Some of its members have suggested that it should reshape itself into a regional Academy with activities generally restricted to the five new states, thereby having a status similar to the Bavarian Academy and other regional science academies in the FRG. It will have to allocate some of its resources, in any case, to activities supporting the state of Saxon-Anhalt, which, beginning in 1992, will provide 20 percent of its budget. Other voices have pointed to the Academy's reputation and broad international membership, and have urged that the Academy build upon this base to develop into a strong National Academy of

Sciences. The FRG lacks national institutions on which to draw for scientific advice, such as the National Research Council or AAAS.

The European Science Foundation may eventually assume this mission, but there will probably remain considerable room for advisory bodies at the national level. The German Science Council provides advice on science policy and has undertaken major functions, including the organizing of peer reviews of the research institutes of the former GDR Academy of Science. However, the council has left a wide spectrum unfilled.

6. It would be a daunting task for the Leopoldina to step in. Its staff is modest and its facilities are outmoded. Unless its membership base is broadened to include engineering, it will not be able to provide advice on many of the technology policy issues faced by the Bonn Government. Despite its reputation, it would have two strikes against it as an East German-centered institute seeking to provide advice to the Bonn establishment. Roles that are more likely within the Academy's reach are in providing advice concerning the rebuilding of S&T capacity in Eastern Germany and in building links to science communities in Eastern Europe. The Academy does have supporters in Bonn who would like to help it play an effective role. Its president, Dr. Parthier, has been nominated to join the German Science Council. Dr. Parthier is also one of two East German scientists invited by the Humboldt Foundation to participate in the high-level U.S./German Science Conference to be held in Berlin on September 9-11. In his capacity as president of Leopoldina, Dr. Parthier will participate in a panel discussion on German Unification and U.S./German cooperation, joining Research and Technology Ministry State Secretary Ziller and German Research Society (DFG) President Markl on the German side and NSF Director Massey speaking for the U.S."

Without considering the rather rare cases in which a school is called an "Academy," the following academies and similar institutions are in the FRG, in addition to the Leopoldina:

- Rheinisch-Westfälische Akademie der Wissenschaften
- Akademie der Wissenschaften zu Göttingen
- Heidelberger Akademie der Wissenschaften
- Akademie der Wissenschaften und der Literatur Mainz
- Bayrische Akademie der Wissenschaften, in München
- Sächsische Akademie der Wissenschaften zu Leipzig
- Aspen Institut Berlin
- Wissenschaftskolleg zu Berlin (Institute for Advanced Study)

and there is a Konferenz der deutschen Akademien der Wissenschaften (Steady Conference of the German Academies of Science) in the town of Mainz (Mayence).

Before 1991, the Akademie der Wissenschaften zu Berlin was the governing agency for most of the non-universitary research institutes in the state. Soon after reunification, these institutes were separated from the Academy, evaluated by the West German Wissenschaftsrat, and organized in new ways. The fate of the Academy itself does not appear to have been decided. Plans to unite it with a West Berlin Academy do not seem to have succeeded, so far.

ANNOTATED STATISTICS

Discussion of the Situation in the Former GDR

The following figures are based on information originally supplied before 1990 by the government or government agencies in the GDR ["Forschung und Entwicklung in der DDR," *Materialien Zur-wissenschaftsstatistik*, issue no. 6, SV-Wissenschaftstatistik im Stifterverband f.d.Deutsche Wissenschaft]. In the period from 1971 to 1989, a clear trend can be observed: the percentage of scientists (among the total number of people employed in Research and Development) was increasing, from about 30 percent to 43 percent, while the percentage of technicians stayed about even at 25 percent. The percentage of support personnel shrank from about 44 percent to 31 percent. During the same period, the absolute number of all these people increased from about 90,000 to 132,000. In a parallel development, the number of scientists with university degrees increased more than the number with somewhat less education,

while the number of support personnel stayed at about the same level.

About two thirds of the people in R&D were employed in the economy (including industry), about one quarter by the state in a more direct manner (Academy institutes, etc.), and the rest (about one tenth) by universities. The world-wide trend to degree-inflation may also have played a role in the GDR. Nevertheless, a trend toward better quality and a little more emphasis on basic science can be assumed. Comparisons of scientific employees in industry versus state are irrelevant because in all cases the state was the employer. Variations may indicate only a change in the organizational scheme.

At the time of reunification, however, these numbers were important because the various sectors were evaluated separately. The total population of the GDR was about 18 million. At that point, there were about 79,000 scientists and engineers in R&D with university degrees, 50,000 with lesser academic degrees, and not quite 70,000 in support positions, giving a total of nearly 200,000 persons working in research and development. These numbers have to be taken with caution; they do not compare very well with numbers derived after reunification.

The GDR's definitions of R&D were not the same as the ones used internationally in the West. Under the Academy of Sciences of the GDR there were 59 research institutions, 45 of which were in the natural sciences and 14 in the humanities and social sciences. West German estimates of research personnel working in these and similar institutes at the time of reunification arrive at between 26,000 and more than 33,000, including more than 50 percent without university graduation.

Survey on Finances for R&D in the FRG

In 1989, 18.2 percent of the overall expenditures for "Science" in the FRG were made by the federal government, either directly or through its support for institutes: 32.4 percent by the länder and communities; 48 percent by industry; and 1.4 percent by nonprofit organizations for a total of DM 89.4 billion. [Most data taken from *Facts and Figures 1990* (FMRT, Public Relations Division, April 1990).]

R&D support by the federal government was provided by the Federal Minstry for Research and Technology (FMRT) at 53 percent, the Federal Ministry of Education and Science at 8 percent; the Federal Ministry of Economics at 7 percent; the Federal Ministry of Defense at 23 percent, and other ministries at 10 percent. Not quite 30 percent of the expenditures are for basic research, a share that has steadily increased at least since 1981. This percentage and the amounts quoted above include expenditures of the federal government for expansion and construction of universities, 85 percent of which is counted here as contributing to basic research (this seems to be a good example of the necessity for being cautious when comparing such figures internationally). Other than that, scientific areas with the highest percentages going to basic research are: marine research (59 percent); economic and social sciences (39 percent); geosciences (39 percent); biotechnology (37 percent); health sciences (37 percent); and space sciences (31 percent).

The federal government, jointly with all or with specific länder governments, supports the Deutsche Forschungs Gemeinschaft (DFG, German Research Society, similar to the U.S. NSF), the Max-Planck Society, The Fraunhofer Society; and in 1990: 13 Large Research Centers (Groß-Forschungs Einrichtungen, GFE, also translated as National Research Centers: 90 percent federal, 10 percent land); 48 Blue List institutes (50 percent federal, 50 percent land); and 102 projects of the Academies of Science (50 percent federal, 50 percent land).

Industrial expenditures for R&D exceed government contributions at a ratio of about 60 percent to 40 percent. They amount (1987) to about DM 45 billion, an increase by 60 percent over the status of 1981. At the same time, the percentage of industrial companies that conducted innovations has increased from 67 percent in 1982 to 76 percent in 1988. DM 26 billion for R&D were spent by companies with more than 10,000 employees, DM 11 billion by companies with 1,000 to 10,000

Table 1 — Research and Development Expenditures

	Total R&D Expenditure (percentage of GDP)			Civilian R&D Expenditure		
Country	1975	1987	1988	1975	1987	1988
FRG	1.23	1.10	1.05	1.09	0.96	0.92
France	1.15	1.38	1.37	0.81	0.88	0.85
U.K.	1.40	1.12	1.06	0.77	0.58	0.55
Italy	0.33	0.76	0.82	0.32	0.70	0.74
Netherlands	0.92	0.97	0.95	0.89	0.94	0.92
Japan	0.60	0.62	—	0.58	0.59	—
U.S.	1.20	1.28	1.23	0.59	0.40	0.40
Canada	0.67	0.57	0.57	0.63	0.53	0.53

employees, the remainder by small and medium-sized companies; 25,000 small and medium-sized companies do their own R&D. A significant increase has taken place in the last ten years.

International Comparisons

Table 1 shows total R&D expenditures as percentages of the gross domestic product (GDP) and percentages of nondefense R&D. These numbers appear to be "exact" but definitions of R, of D, and of "defense R&D" (and other concepts, e.g., "budget") are not the same in all countries.

Additional information with annotated statistics are provided in our Report, Part A.

COLLECTIONS OF RESEARCH DONE OR IN PROGRESS

In the U.S. and in the FRG, efforts have been made to collect relatively detailed information on both research results and projects in progress. This information is stored either in libraries or in data banks, accessible either in the traditional way or by electronic means, for example by calling key words. The data banks are quite comprehensive. It is not possible to give here all details needed for their use. Catalogs, manuals, or other user material can be requested from the agencies and organizations quoted below.

Collection on Research in the FRG by the Library of Congress

The Library of Congress in Washington, DC, in its Technical Reports Section, Science and Technology Division, has established a special collection of information material on research in the FRG. This collection includes reports, brochures, etc. (including those listed in this report), to be routinely supplied by the German agencies and organizations from which these originate. The material can be investigated in the Library but it is also possible, to a certain degree, to investigate remotely. [See **Practical Hints**, p. 120, in the present report.]

U.S. National Technical Information Service (NTIS)

The NTIS, established in 1945, is located in Springfield, Virginia, just outside of Washington, DC. It is a self-supporting agency of the U.S. Department of Commerce and the largest single source for public access to federally produced information. Each year, approximately 70,000 summaries of completed, and 120,000 reports of ongoing U.S. and foreign government-sponsored research and development and engineering activities are added. Its collection of 2 million works covers current sciences and techologies, foreign and domestic environment, energy, health, social sciences, business and management studies, trade, general statistics, translations of foreign reports and hundreds of other areas.

The material is not limited to printed reports and documents; computer software and data files are on tape, disk, and CD-ROM. More than 200 federal agencies contribute to the collection, including the National Science Foundation; National Aeronautics and Space Agency; Environmental Protection Agency; National Institutes of Health; and Departments of Defense, Agriculture, Energy, Commerce, Interior, Health and Human Services, and Transportation. Nearly one-third of new additions now come from foreign sources (including Japan, East Europe, and Russia). NTIS can deliver the full text of 90 percent of the 70,000 documents it announces each year. A number of printed and electronic awareness services are available for researchers, educators, managers, and librarians.

STN International Columbus

STN International, located in Columbus, Ohio, offers on-line service and products. It is a nonprofit organization, operated in North America by CAS, a division of the American Chemical Society and in Europe by FIZ, Karlsruhe (see below). Its *Mid-Year 1991 Database Contents Guide* describes 112 databases in English and/or German and also some in French or Spanish; 39 of these databases are of German origin. Tutorial services to learn the various search possibilities are offered, access can be made from personal computers.

FIZ (Fach-Informations-Zentrum) Karlsruhe

FIZ, located in Karlsruhe, houses the STN International Karlsruhe, which appears to be very similar to STN International Columbus (see above). Its booklet *STN International, Datenbanken aus Wissenschaft und Technik* describes 117 databases. Many of these databases would be very useful for American scientists wanting to know what is being done in Germany in their own field. For example, *PHYS*, produced by FIZ in cooperation with the American Institute of Physics and the Astronomical Mathematics Institute in Heidelberg, evaluates books, reports, nonconventional sources, conference contributions, and 22200 scientific journals to cover 11 branches of physics. Every second week, more than 5000 quotations are added. From 1979 through 1992, more than 1.5 million quotations have been accumulated. Another database of special interest is *FORKAT*, which reproduces the information of the *Förderungskatalog* of the Federal Ministry of Research and Technolgy in Bonn. FORKAT is also described as the in-house database of the FMRT. From 1984 to September 1990 it collected 14,708 research projects, and it is reloaded annually. It does not contain reports of sponsored projects; for these see the data bank FTN, also by STN.

Technische Informations Bibliotek Hannover

This technical information library at the Technical University of Hannover offers, among other services, what it calls "TIBQUICK, the quickest way to scientific literature, on-line orders, fax-delivery"—if necessary, within two hours. It supplements certain electronic data services and can quickly supply the full text of reports. It was established in 1959 on the basis of the Hannover University Library, which was founded 1831.

AMERICAN/GERMAN EXCHANGE AND COLLABORATION

A large number of agencies and organizations, both in the United States and in Germany, are fully or significantly dedicated to American/German interactions; these are varied and are probably still increasing. We can discuss only a selection of

them, and we tried to find those that are most important in the context of this report. In the following, we restrict ourselves to short descriptions of the goals of these organizations. Significant additional information is provided in our Report, Part A. Large scientific associations in both countries often have special departments for foreign affairs, usually headed by a senior scientist with extensive knowledge of other countries and sometimes maintaining a special staff. We do not consider here associations or other organizations that are specialized or encompass only a limited number of scientific disciplines—their number would be too large for this report; we attempt to list those that are more generally oriented.

American Agencies and Organizations

The *American Association for the Advancement of Science* (AAAS) has a Directorate for International Programs. These programs include (among many others): the Global Change Program, the International Scientific Cooperation Program, and the Program on Science and International Security. This Directorate, together with the Alexander-von-Humboldt-Stiftung of Germany (see below), conducted a "Seminar on Bilateral Cooperation in Science and Technology between the United States of America and the Federal Republic of Germany," 9-11 September 1991, in East Berlin. This seminar had been preceded by a similar one held in Washington, DC, in 1987. In Berlin, three groups of topics were discussed: contacts between individual scholars, scientists and engineers; joint research projects; and joint studies on policy issues and problems. The participants also suggested that leaders of the U.S. and German scientific and engineering communities establish a regular forum to facilitate cooperation between the two countries.

The *National Science Foundation* (NSF) has a Directorate for Scientific and Technological and International Affairs, including a Division of International Programs. In October 1991, this division produced a small brochure, "Western European Program Announcement." For some countries, special notes were added. For the FRG, they read as follows:

> "GERMANY. No counterpart proposal submission is required at this time. German scientists may wish to inquire about financial support from the International Relations Division of the Deutsche Forschungsgemeinschaft (DFG) at Kennedyallee 40 (or Postfach 20 50 04), D-5300 Bonn 2. Applicants interested in submitting proposals for collaboration with the Gesellschaft für Mathematik und Datenverarbeitung (GMD) should contact the U.S.-Germany Program Officer for further information. Their German counterpart should contact the International Department of the GMD, Schloss Birlinghofen, Postfach 1240, St.Augustin 1."

U.S. Department of State, the Assistant Secretary of the Bureau of Oceans and International, Environmental and Scientific Affairs, is the correct address in matters of international scientific cooperation involving the Department of State.

The *German Marshall Fund of the United States* is an American organization supported by grants given by the German Bundestag. Its purpose is to promote a more informed understanding of differences that arise between Europe and the U.S., and to stimulate exchange of practical experience on common problems confronting modern industrial societies. The scope of activities is very broad; many of them are carried out in cooperation with other institutes or organizations and are not restricted to German/American relations.

The *Congressional Study Group on Germany* consists of about 80 "members" and more than 10 "associate members" who are all members of the U.S. House of Representatives, and about 20 "members" and more than 10 "associate members" who are all in the U.S. Senate. A former German ambassador to the U.S., Jürgen Ruhfus, defined this group as the "crown jewel of German-U.S. relations and the cornerstone of the German-U.S. legislative relationship." The sister group in Germany is the Deutsch-Amerikanische Parlamentariergruppe of the Bundestag.

The *American Council on Germany* is a private, nonprofit organization dedicated to promoting economic, political, and cultural ties between U.S. and German citizens and institutions. This is done through exchanges of young professionals, conferences, study tours, sponsored speakers, and publications.

The *American Institute for Contemporary German Studies* (AICGS) of the Johns Hopkins

University is one of several Washington-area universitary institutes that offer studies about Germany and also frequently present lectures and discussions to a wider audience, often with prominent visitors from the FRG.

The Georgetown University *Center for German and European Studies* is related to the German Department at Georgetown University. It conducts a series of open lectures on German and European contemporary topics.

The *Woodrow Wilson International Center of Scholars* was established 1968 by the U.S. Congress as an international center for advanced study, "symbolizing and strengthening the fruitful relation between the world of learning and the world of public affairs." Chosen in annual worldwide competitions, some 50 Fellows at the Center carry out advanced research, write, and join in discussions with other scholars, public officials, journalists, and business and labor leaders.

Institutes of American Universities in Germany: A number of American universities have established educational and scientific centers in Germany—some already a long time ago. To quote just one example: "The University of Maryland University College in Schwäbisch Gmünd, Germany, under The University of Maryland University College International Programs in College Park, MD. Bachelor's degrees can be earned in four disciplines; the institute also offers possibilities for a Junior Year Abroad, with special-topics courses. The student body is international." For information on other such colleges or institutes of American universities in Germany, contact the Institute of International Education.

The *German Language Society* in the Washington, DC, area, holds regular lectures and discussions by and with promnent visitors from the FRG, Austria, and Switzerland, unsually in one of the three embassies.

The *German-American Cultural Fund* annually conducts one or two relatively large German events (e.g., exhibitions of art) and also presents the Carl-Schurz-Lecture series at the Library of Congress.

European Offices of American Government Agencies Promoting Scientific Research

The *U.S. National Science Foundation, the U.S. Army, U.S. Navy, and U.S. Air Force* maintain offices in Europe to promote international coordination or collaboration. For the Army and the Air Force, these offices can provide grants for scientific research to European scientists and scientific institutes; the Navy can assist with visits to the U.S. or conduct small conferences on a high scientific level—to provide information on European science to Americans and vice versa.

The *Institute of International Education* was internationally known long before World War II. It promotes international education at all levels. The U.S. Department of State and the Board of Foreign Scholarships has designated it to administer grants for study abroad and for college-level teaching fellowships and assistanceships. It also offers exchanges, training, and internships, research support, and home-stay programs. The grants are for both long and short durations.

The *Fulbright Program* is funded and administered by the U.S. Information Agency. Funding is also provided by participating governments and cost sharing by host institutions in the U.S. and many countries. The presidentially appointed J.William Fulbright Scholarship Board is responsible for providing policy guidance for the program and for making the final selection of all grantees. Two-way exchanges occur with all countries in the world. About 1000 scholars are involved every year in each direction (coming to the U.S. and going abroad), with Europe being the main exchange partner.

German Agencies and Organizations

German Foreign Office, Bundestag and Länderparliaments — The Auswärtiges Amt (Foreign Office, Ministry of Foreign Affairs) of the German federal government, has created a special office concerned with a narrowly defined but still rather broad official task within the relations between the U.S.and the FRG. The position of the head of this office is Koordinator für die deutsch-amerikanische zwischengesellschaftliche, kultur- und informationspolitische Zusammenarbeit, the approximate translation of which is Coordinator for the German-American collaboration in the fields of relations between the two national communities; the field of the politics in the domain of arts, music, and other cultural activities; and in the field of politics of mutual information." The

closest partner on the American side is the Interagency Steering Committee on U.S./German Contacts (U.S. Information Agency, Washington, DC). This Office in Bonn has issued a number of very useful and informative booklets, e.g., a long list of addresses of organizations in both countries dealing with mutual interactions; or fundamental considerations of the values of American-German interactions. Also, a plan for a joint American/German Academy of Sciences has been worked out and was discussed by President Bush and Chancellor Kohl in Washington in the spring of 1992, followed by continuing negotiations.

The German Parliament, lower house (Deutscher Bundestag) has constituted a *Deutsch-Amerikanische Parlamentariergruppe*, which has as its American partner the Congressional Study Group on Germany. There is also a special organization of delegates in the parliaments (Landtage) of the German länder (and some other members), promoting meetings and exchange with delegates of the houses and/or senates of the American States; this is called Partnerschaft der Parlamente and is located in Berlin-Schöneberg.

German Academic Exchange Service (DAAD) — The Deutscher Akademischer Austauschdienst (DAAD) was founded during the Weimar Republic in 1925 and refounded for West Germany after World War II. It has developed into one of the leading forces in cultural exchange between the FRG and other countries and may now be the largest organization of this kind anywhere. Its activities have multiplied and broadened over the years, and again so in this transition time of the reunification. The DAAD is an institution of the German universities and other colleges and schools of higher learning, legally a licensed nonprofit organization. Within the FRG, the tasks of the DAAD at the individual universities, etc., are usually represented by the Academic Foreign Offices (Akademische Auslandsämter) which are, however, organizations of the universities or other bodies, not of the DAAD itself. Outside of the FRG, the DAAD maintains offices in Jakarta, Cairo, London, Nairobi, New Delhi, New York, Paris, Rio de Janiero, San José (Mexico), and Tokyo. Reports from these offices constitute an interesting part of the Annual Report of the DAAD. Directors of these offices analyze the educational and scientific situation in the respective countries; by necessity, this also involves political analyses. The Annual Reports also give detailed information on the distribution of the activities to various programs and to various countries or continents.

The *Humboldt Foundation* — The Alexander-von-Humboldt-Stiftung was founded in Berlin in 1860. It was refounded in 1953 by the Federal Minister for Foreign Affairs as an incorporated foundation in private law. Its presidents since then have been Werner Heisenberg, Feodor Lynen, Wolfgang Paul, and Reimar Lüst. The latter was formerly president of the Max-Planck-Society and Director-General of the European Space Agency. According to its statutes, the purpose of the Humboldt-Foundation is:

> "...to grant research fellowships and research awards to academically trained and highly qualified persons of foreign nationality...to enable them to carry out research projects in the Federal Republic of Germany, and to maintain the resultant academic contacts..."

From 1953 to 1988, almost 11,000 scientists holding doctorates and being younger than 40 years of age came to Germany (including West Berlin) through the Foundation. Among these, more than 1,200 have come from the U.S. Their research projects have durations of 1 to 2 years; each year about 500 researchers participate in the program.

The *Atlantik Brücke, e.V.* (Atlantic Bridge), organized and incorporated as a private, independent, nonpartisan, and nonprofit association, was founded in Hamburg in 1952. Members and sponsors come from business, politics, the sciences, the media, and trade unions. Membership is by nomination and invitation only. The association is financed by members' contributions. The Atlantik-Brücke seeks to strengthen both understanding of the FRG in the U.S. and Canada, and of the U.S. and Canada in the FRG. In particular, it promotes and arranges personal meetings between Germans and Americans in economic, political, and cultural centers of both countries. In addition, the association conducts informal and publishing activities and cooperates with persons and institutions engaged in similar efforts. American organizations currently

cooperating with the Atlantik-Brücke include the American Council on Germany, Inc. (New York), the Council on Foreign Relations (New York), The Woodrow Wilson International Center for Scholars (Washington, DC), The American Assembly (New York), the American Jewish Committee (New York), and the Armonk Institute for the Promotion of German-American/Jewish Relations (New York).

The *Goethe Institute*, founded 1951, works to distribute knowledge of the German language and to foster international cultural collaboration in general. In addition to 16 institutes in the FRG, it has 157 institutes in 73 foreign countries, employing more than 3,000 people. German government resources contribute about DM 270 million; about DM 65 million more is earned from language courses conducted in the FRG. In the U.S., there are Goethe Institutes in Ann Arbor, MI; Atlanta, GA; Boston, MA; Chicago, IL; Cincinnati, OH; Houston, TX; Beverly Hills, CA; New York, NY; San Francisco, CA; Seattle, WA; St.Louis, MO; and Washington, DC.

The *German Historical Institute Washington*, one of a series of German scientific institutes in other countries, was founded 1987 as a nonprofit private foundation funded by the German government but open to support from other sources. The Institute is independent in its scholarly activities. It provides a permanent basis for the cooperation of historians and political scientists from the FRG and the U.S. It promotes and supports historical resesarch in various fields, including American history. Conferences, lecture series, scholarships, several series of publications, and the maintenance of its own library are among the tools used.

Two other types of German institutes should be briefly mentioned here (more on them in our Report, Part A): Foundations related to the four major political parties in Germany, and American representatives of German scientific institutes, e.g. the National Research Centers.

With regard to *foundations related to the four major political parties*, the German Constitutional Court expressly stated a few years ago that they have special obligations and programs apart from those of the related Parties. They represent a uniquely German form of organization, dealing with fundamental politics and thereby constituting an element of stability; they promote fundamental political research (in part in special institutes within the foundation) and thereby also in basic political education. International collaboration, including exchange of parlamentarians, politicians, journalists, and scientists, is an important part of their programs, with much emphasis on collaboration with Third World countries. All four political parties also maintain permanent representations in Washington, DC, and in other countries. Each maintains several institutes and has several hundred employees.

These four organizations (including year of founding and related political party) are:):

Konrad-Adenauer Stiftung (1964), CDU;
Hanns-Seidel-Stiftung (1967), CSU;
Friedrich-Naumann-Stiftung (1958), FDP;
Friedrich-Ebert-Stiftung (1925), SPD.

Our Report, Part A, provides more information, names, and addresses.

As previously noted, *large German scientific institutions*, especially the National Research Centers, maintain wide international liaisons, sometimes supported by a representative and a staff in the United States. We mention here only the Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR, formerly DVFLR), i.e., the German Aerospace Research Establishment, which maintains an office in Washington, DC.

Agreements, Common Experiments

There is little doubt that in most cases a direct collaboration between scientists from different countries is the most fruitful form of coordination, with direct collaboration between research institutes as the next desirable possibility. Experience shows that the smallest probability for friction between the collaborators is the system in which each nation pays its own share. In this scope, the international transfer of instruments, scientists, and/or finances may occur as exceptions, to be handled separately for each case. Government research-promoting agencies then may have a national and an international role. The national one, direct financial support of research, remains within each nation. The international role is advisory and assisting,

helping in finding contacts and conducting programmatic meetings and data exchange, etc. Especially in the field of the environmental sciences, where international experiments or field excursions are often necessary, this form has produced the most useful results.

However, there are cases in which more legally binding forms are required. A common vehicle for such cases is the bilateral Memorandum of Understanding, negotiated between two governments or their agencies and officially signed. Because legal questions (in the case of U.S. involvement, often with countries having very different legal systems) always seem to occur, often unexpectedly so, negotiations of this kind tend to take a long time; it is prudent to assign a period of two years from the first discussions to the signatures. If bilateral agreements already exist (for example, between the research departments of Ministries of Defense in the form of Data-Exchange Agreements), they may serve as starting negotiation points. If they happen to be active in the particular scientific field of interest, NATO Research Study Groups or Panels of the NATO Scientific Affairs Group may also be helpful.

American research-oriented agencies sometimes have relatively large, long-standing agreements with similar organizations of other nations or with international bodies (e.g., the United Nations, the European Space Agency), under which individual scientists or institutes may apply for participation in international research programs.

DISCUSSION

After a brief introduction, this section discusses the following topics:

- Basic Ideas on American/German Collaboration
- General Level of Science in East Germany
- Research Institutes in East Germany - General Background
- Situation after Transition
- Opportunities and Recommendations
- Practical Hints,

and provides a brief Conclusion.

Introduction

This chapter reflects the personal impressions of two German-speaking Americans and is based on recent visits in the five new länder of the FRG and on discussions and reading as well as on experience in living in the area before World War II. The chapter cannot claim to give a complete review; changes inflicted on the people and the land have been profound, and readjustment is still in flux.

The authors also present personal conclusions drawn from their experience. This is done in the hope that they will be helpful to American scientists interested in obtaining information on, and/or establishing scientific contacts with, colleagues and institutions in East Germany, especially with those who have had no chance yet to become internationally known by publications and conference papers.

Basic Ideas on American/German Scientific Collaboration

Although the attitude that each of us should help the other is laudable, permanent and fruitful interaction must be based on promoting one's own scientific side by interacting with the other side. That must be understood by both American and German scientists and science-promoting agencies. Looking more closely into the potential, we offer the following ideas.

President Reagan's speech at Hambach in the FRG, and President Bush's note of "partners in leadership" signaled a new American attitude with regard to the FRG, emphasizing that this in no way will reduce the traditional friendship between the U.S. and the U.K., France, and other European allies. By stating this, the U.S. indicated that the nature of the American/German interaction may be of a different nature, without defining that nature—indeed, it should not be defined, at least not yet, because it must develop.

This attitude was confirmed by the Partners in Leadership: The Need for Enhanced Engagement (Partner in der Führung: Die Notwendigkeit stärkeren Engagements) speech. This speech was given on 5 September 1991 by the new American Ambassador in Bonn, Robert M. Kimmit, to the

Atlantik Brücke. (It is available in English from: U.S. Embassy Bonn, USIS, Press Attaché; in German from: Rundschreiben Nr. 7/1991, Atlantik Brücke e.V., Adenauer Allee 131, D/W-5300 Bonn 1.) This attitude was also confirmed by his first interview with a leading German newspaper, conducted with its editor, Dr. Thomas Kielinger ("Natürlich ist Deutschland ein starkes Land," *Rheinischer Merkur*, No. 11, S.6, 13 March 1992.) An informal English translation has been made by the U.S. Embassy in Bonn, 11 typwewritten pages.).

One of the first steps in this development was announced by Chancellor Kohl after his visit with President Bush at Camp David: he and his host (President Bush) had agreed to found an institution; the Germans have given this the preliminary name, the American - German Academy of Science. Some years earlier, such a foundation had been suggested and prepared within the German government by Chancellor Kohl after extensive meetings with leading American scientists and science administrators.

These general and high-level developments pose the question to American researchers and research administrators as to whether or not they should join this development and, if so, in which way. In particular, our specific discussion on research in East Germany is confronted with this question. It turns out that any support of general, high-level development of scientific American/German relations must consider the research situation in the five new länder and East Berlin as part of the situation in all of the FRG. This is reflected in our presentation of the agencies and organizations above. The question of whether or not the development should be supported is, upon closer consideration, a moot one. The pressure for research cooperation between the U.S. and other countries, especially in Europe, will increase. There are specific reasons to include the FRG in such efforts.

The American and German systems of primary and secondary education are different. This difference becomes smaller and finally seems to disappear at the graduate and postgraduate level. The result is that the similarities in scientific research by far outweigh the differences. It is, however, of interest to assess the still-remaining differences. Some of them are caused by the stronger government influence in the FRG as compared to the U.S. Instead of attempting to give a theoretical definition of these differences, we provide a few examples.

We compare the situation of the U.S. National Science Foundation (NSF) with that of the German Deutsche Forschungs-Gemeinschaft (DFG). In a purely legal sense, the German organization may seem to be less dependent on the government; the DFG is a private, nonprofit organization, while the NSF is part of the government. Even if in reality the difference is not quite as great as it seems (the DFG gets nearly all its money from the government), this form gives the DFG a slightly greater flexibility than NSF has. Essentially, however, there are important differences: in the FRG, scientists are designated to provide peer review for proposals; in the U.S., NSF science officers are free to select the proposals that they review (there are exemptions in both cases). This imposes a far greater rigidity on the German system than would be acceptable by Americans.

The fact that in the FRG practically all universities are state schools and that many research grants do not involve private parties modifies many problems of overhead or conflict of interest. In addition, if these problems still exist, they are less likely to surface.

Another interesting difference is that (for example) in the U.S. a university professor may leave his chair and join one of the research-supporting agencies (e.g., NSF or ONR) for either one to two years in a kind of guest role, or permanently, while vice versa, it often happens that a program manager, scientific officer, division director, etc., in e.g., ONR or NSF may decide to return to research and/or teaching and join a university or research laboratory. Transitions of this type seldom occur in the FRG.

Considering the research situation in non-university institutions, we may find more similarities between the two countries. Still, a larger percentage of such institutions are firmly state supported or owned by the government

in the FRG than in the U.S. It is often stated that dependence on the government is also increasing in America. This may be true, but it happens in a less regulated form than in the FRG, leaving a greater flexibility.

Whatever the differences or similarities, the American scientist (as well as anyone else) who seeks scientific interaction with the FRG will find it relatively easy to find what is being done in research in the FRG because of the thoroughly organizational form. If both sides are equally interested in collaboration, initiation should come from the American side; it is easier for us to pursue.

The most important partners for German international scientific collaboration are the countries of Western Europe, inside or outside of the various frames provided by the European Community (EC). German scientific relations with Third World countries are also strong—and they are now extended to Eastern Europe.

The United States has always been an important partner for German international scientific relations. There are, however, distinct differences. Directly competing with American institutions in scientific fields in which Americans clearly have a leading position has become relatively rare, restricted generally to fields in which there are strong reasons for a national effort. Instead, prudent German scholars are known to seek fields in which the American effort is absent or weak. Such a selective process may take place on several levels. This development has the potential for a fruitful and enduring form of cooperation. In one favored view of the FRG as the Junior Partner in its relationship to America, the concept of Arbeitsteilung has an important place: Arbeitsteilung means that each partner does what he can do best and for which the other partner may have less abilities or less inclination, while both are in agreement that each part of a common task must be cared for.

Although the Arbeitsteilung concept also plays a role in German scientific relations to other countries, say in Europe, a German hope that they could change what the Americans are doing is still rare. Whether it will remain this way or not is an interesting and important question. The American scholar dealing with Germans must be aware of this German attitude and the hidden potential for its change in the future. Whenever the American might be in a position to offer a change in the American selection or execution of a project, he may have a bargaining tool in his hands.

Considering (a) our long-standing familiarity with both the German and the American structure, attitudes, and tendencies in science and research; (b) the substance and the tenor of the discussions in the five new länder, from the Staats-Sekretär and the University-Rektor to the young Ph.D's at their desks and laboratory benches; and (c) the programs of the agencies, organizations, foundations in the FRG and in America that we have collected for this report...

....We detect with some surprise that these programs do not reflect any promotion of the special and specific task of combining the enthusiasm and spiritual hunger that we met between Jena and Greifswald (despite some widespread disappointment) with the experience, expertise, and flexibility of their American colleagues and counterparts.

There are many programs for the political or social sciences, history, law, economy, business, mass communication, languages, and special programs for journalists, politicians, and teachers. These are all important and needed, but they are only marginally (if at all) concerned with the hard sciences. This neglect is counterproductive. In contrast to the fields quoted above, the natural sciences start from an internationally shared basis of natural laws, theories, and results. Therefore, when scientists from different countries meet, a solid consensus already exists. Cases are rare where major controversies arise. Beyond their specific research, they share an interest in general topics. By the nature of their work, they may be more rational in approaching questions of general interest outside their fields.

To summarize our experiences from the five new länder, all those voices ring loud who said:

> "Send us a few young Americans who bring with them the pioneer spirit, ready to push up their sleeves and start doing things—give us American scientists for a few years to direct our institutes, to teach us how to manage research and how to market it—we would like to visit the U.S. to see how these things are

done, to become aware of new scientific trends and needs to be taken care of—not in competition with the work of our West German colleagues but in supplementing what they do—we simply must find out directly how the American image had been distorted by our former government—we also think that we could and should do what the Russians now practice in their new relationship with America..."

Indeed it should not even be necessary to hear such voices. Simple observation and reasoning should tell us that well founded and carefully defined actions or specific programs for scientsts and institutions in the five new länder and East Berlin are called for, and that the American potential must be tapped. Present shortcoming are probably caused not so much by lack of funds as by lack of initiative and organization.

General Level of Science in East Germany

From the Thirty-Years War (1618-1648) until 1871, Germany was a quilt of frequently changing and practically independent principalities of various and varying sizes, keeping a memory of the former powerful Holy Roman Empire of the German Nation more or less alive. After 1648, the power of the Emperor, outside of his own principality, was almost nil. The concept of a German identity persisted in the minds of most people, but it was not subjected to the workings of a common government. This situation was favorable to the rise of a multivaried spiritual life, especially in the period of the Enlightenment and thereafter. The general level of knowledge and of creative spiritual ability in Germany at that time was comparable to that of the West European nations and North America. After the German unification of 1871, this high level was maintained and manifested itself in an excellent university system and in nearly all areas of cultural life, also supporting a high level of industry. Free expression of independent thought was somewhat restricted in the Kaiser-Reich (1871-1918), leading to the uncertainties typical of the Weimar Republic (1918-1933). After 1933, it was totally suppressed by the Hitler government and was only won back in the Eastern part in 1989/1990. It is important to remember that the people in the five new länder did not experience free discussion for a period of almost 60 years.

During this period, the high level of university education and research could not be maintained throughout, but the decline was not a general one, nor did it occur in all branches to the same degree. The necessity to maintain a fairly high level in the natural sciences and engineering, for example, was dictated by the continuing needs of industry. In addition, after 1945 the former German Democratic Republic increased its contact with scientific institutions in the U.S.S.R. and other Warsaw Pact states. In this process, the GDR did not fare badly; in some branches of science it became the leader. Maintaining a high level of science education at East German universities was in the best interests of all, even if in some critical points, political reasons were given preference. Suppression of freedom in teaching and research had catastrophic consequences in the humanities, under Hitler and later in the GDR. Even there, however, a small number of researchers were able to find niches where they could do good work that was of little interest to the politicians.

The East German population that is emerging from communist rule shows a low level of general knowledge on broad fields of the humanities, especially history, global geography, jurisprudence, Western languages, modern literature, and, of course, political and social sciences. This is less pronounced in those whose parents were able to inform them better than the schools did. However, on the average, we find an acceptable level of knowledge in the sciences, from mathematics to physics, chemistry, and biology or the medical domains. This is true at all levels, from elementary school to postgraduate university. In spite of this acceptable level, the substance of such knowledge may often be different from that of the West.

[Some gaps opened in the fields of environmental science. These fields were, in part, seen by the government as potentially hostile to its actions. The world now knows of the enormous and often catastrophic pollution and deterioration of the human environment—the air, rivers, lakes, and soil—in the East Bloc countries. It is also obvious that the governments there were to blame for this severe situation. Therefore, in a former East Bloc country, to find something bad with regard to pollution—indeed to know the facts about it—was

dangerous. In the opinion of the authors, West German television (which could be seen in most parts of the GDR) can hardly escape blame for not having informed the people about these dangerous or even fatal facts.]

Obviously, scientists in the five new länder will know more about the work done in Eastern countries and less about the Western situation than most of their Western colleages. But the differences also extend to scientific knowledge itself, as a result of the strong isolation imposed by the government of the former GDR. While colleagues at the East German institutes may often be ignorant of details in the latest Western scientific progress, in some cases they found their own different ways and new results. Differences in scientific level between the institutes in the former GDR and the West will be discussed later.

In the GDR, as in other East Bloc countries, the distribution of scientific knowledge, as good or bad as it might have been, among the social strata of the population was different from that in West European countries. Communist governments introduced means to get university students from families that otherwise would not have considered such an education for their children, while often children from some better situated families may have encountered obstacles that were impossible or extremely difficult to overcome.

As to foreign languages, Russian was mandatory; some could also learn English. Among those scientists who had no English in school, we may find a significant percentage who studied it on their own, which is an impressive achievement. There was not much free time for this purpose: after the common working hours, many evenings and/or weekends were occupied by mandatory political and military training. They studied English because they were convinced that one day they would need it to become a member of the international scientific community. It may have been risky to openly show such a conviction.

When looking at the situation in the five new länder as they emerged from nearly 50 years of communist rule, and seeing the often desolate conditions there, one should, however, not forget one important fact: Before World War II, this had been one of the most prosperous regions of Germany. A large percentage of industry (such as aircraft, automotive, electrical, heavy machinery, and textiles) was located here. About 65 percent of German industrial exports originated here. In some ways, this region was a worldwide leader; the population had the reputation of being industrious and innovative.

A cautious promotion by West Germany may result in the return of these values and potentials. German Telekom claims that they are constructing a telecommunication network here that will be the most modern in Europe. In other fields, also, the advantage of beginning from scratch with sufficient outside help may produce a second, albeit different "German Miracle." There is the expectation that in 15-20 years this area will be ahead of the Western part of the FRG in many aspects.

It goes without saying that this development will have a large influence on the Research Landscape.

Research Institutes in East Germany - General Background

These are impressions. As such, take them with caution. We think that our impressions are quite descriptive of approximately 60 percent of the institutes, in spite of their differences. Furthermore, the situation described may be taken as an average of the other 40 percent; however, deviations in both directions may be large.

The building of a new research structure has been mentioned, including the fact that errors have been made in that process. As a whole, however, many will agree that the task has been better performed than most people involved had dared to hope.

Others, for example the President of the Science Council (Wissenschaftsrat), Prof. Dieter Simon, had hoped that the total German scientific structure could be reformed, taking advantage of the radical political changes. According to two articles in the *Frankfurter Allgemeine Zeitung* (19 March and 30 December 1991), he had hoped that a critical review of certain parts of the German system of education and research could be conducted and was disappointed that this did not occur. According to the *Rheinischer Merkur* of 21 February 1992 (Rainer Klofat, "Weichensteller auf neuem Terrain," *Rheinischer Merkur*, no. 8, p. 15), Simon thinks that it is not yet too late for such

a fundamental investigation but, as he stated at a different occasion, it is in the hands of the politicians.

As already pointed out, most (but not all!) of what Western scientists would call "research" was done in non-universitary institutes. These institutes were mostly under the Academy of Sciences in Berlin, with most institutes also in East Berlin.

For the GDR government, the political reliability of the directors of these institutes was often more important than their scientific abilities. Again, this does not apply to all of them. Also, being believed as being politically reliable does not necessarily destroy the ability to do good scientific work. We have been told that there were institutes in which all the scientists including the director were against the government. However, to protect their employees, directors had to find some compromise with the government. This then may have made them victims of the purification after the reunification. This purification had been quickly and strongly performed. As a consequence, some scientists found themselves (to their own surprise) in the position of acting directors of their institutes in a most difficult time. They also wanted and had to continue their scientific work. But, in a third capacity, they had to partially turn into politicians to protect their institutes. To do good scientific work in these institutes was difficult. But nevertheless, it had to be done and (according to our own observations and those by other visiting Americans) generally was done.

Contacts with the scientific world outside the Eastern Bloc were generally rare and difficult to maintain. Letters from the West did not always arrive; it often was unknown whether or not letters to the West were forwarded. Publication in prestigious Western journals was generally impossible because hard currency for page charges was not available. Travel to the West was always difficult, but in the 1970s the Reisekader (Travel Teams) principle was introduced. This permitted only a restricted group of persons to travel, not necessarily the experts in the scientific field in question. Therefore, few papers by East German investigators were presented at significant Western conferences. Of the traditional scientific journals, possibly one copy was subscribed to for an entire university town; it was almost impossible to get new journals. (Again, there were exceptions, e.g., when the government thought that a particular journal was essential for a particular scientific task they wanted to promote.) Powerful and reliable computers were practically unobtainable, as were scientific instruments from the West.

Working under such conditions was very difficult and also required that certain attitudes and skills be developed. We were impressed by the scientific ethic of many of the colleagues we met. Obviously, they could see their work as being meaningful only if they believed that doing something for science has merit in itself. Guidance from above was often missing or useless. Details of new Western scientific insights, paradigms, and theories were not always available; one had to develop hypotheses of one's own. Measuring instruments often had to be designed, developed, and built independently. This was not an economical method, but it did produce some interesting results, experimentally, in understanding the limitations of experimental data, and sometimes in arriving at new solutions for measurement problems. Likewise, working with the inadequate Robotron computers often required that unique and individual methods and programs be developed.

Some deep disappointment among the scientists in the East was expected after reunification. From their point of view, the scientific ethic of their colleagues in the West left something to be desired. They sometimes had the feeling that preoccupation with their own work blinded the Western scientists to the potentials and needs of their Eastern colleagues. In other cases, fear of competition from the East seemed to be sufficient reason for negligence or even hostility. It is difficult to determine whether or not such attitudes are warranted by facts. I believe that sometimes they are, but we must not forget that the people in the East had been trained by their education and their newspapers to expect attitudes of this kind from the West. Even without such disappointment, it is difficult for people in the East to understand Western ways of progressing. How do you have to act in order to convince a Western colleague that your proposal has merit? How do you manage research so that you get results of interest to the West—and also in a way that convinces Western colleagues that you do it correctly? How do you market your own

scientific and research potential and that of your colleagues, your institute? How do you market research results?

There are cases in which researchers working at an institute in East Germany were convinced that they had made a scientific breakthrough and now believed that this would be highly welcomed by their Western colleagues. This did not happen. The researchers' newly obtained access to the state of the art in the particular field showed them that indeed they had made a breakthrough. However, all they encountered from their Western colleagues was benign or even hostile neglect.

These problems beg solutions. We heard from leading West German institutions that they are developing methods to overcome these prejudices, step by step. Such efforts are not always welcomed in the East. The Marxist ideology did not always die with the Marxist state. Here and there we encountered the opinion that this ideology is basically good but was applied in a wrong way. This opinion may result in an inner resistance to even the best-intended and most promising West German efforts. We cannot expect that all West German contacts are equipped to deal with such ideological problems.

Do we find here a motivation for the call (which, as noted above, we heard several times during our visits) to send young Americans to work in East Germany for a few years—to roll up their sleeves and instill the pioneer spirit as well as the basic facts of democratic life and democratic government?

Situation After Transition

For any consideration of interaction with scientists and institutions in the five new länder and East Berlin, the first question to be asked is "what is the relative quality level between them and their Western colleagues."

First, let us briefly state our opinion that we arrived at after looking into the situation. We would not have spent the large amount of work invested in these reports and into the collection of information needed for them if we had not been convinced that it is worthwhile. In one sentence:

The general Western belief that because we did not hear about the scientific achievements obtained in East Germany, the scientific level there must be low, turned out to be wrong.

This requires a broader and, above all, deeper discussion.

It will take five years or more until East Germany reaches the same level of quality of life that is enjoyed in the Western part of the Federal Republic. This progress will not be even; rather it will occur in spurts—different in every aspect. Rebuilding the main roads and establishing a very modern communication system can certainly be done in less than five years, and by then every large or medium-size town will have at least a few streets and a few quarters that please the eye and are comfortable for the people living there. Refurbishing the other parts of the town and the remainder of the roads will take much longer than five years. Whether the less-used lines of the railroad network will be maintained, and how quickly the Deutsche Reichsbahn (Eastern railroad system) will be comparable to the Deutsche Bundesbahn (Western railroad system) is difficult to predict. The plans for high-speed magnetic levitation trains between Hamburg and Berlin, Bonn and Berlin, and Dresden and Berlin are less visionary than they may appear to the American observer: the need for such a system and the expected benefits from it are much stronger for a country like the FRG than they are for the U.S.

Predicting the development of the "spiritual infrastructure" is more difficult. The understanding of the fundamental concepts of democracy by the leaders and the people, the evolution of a modern and democratic judicial system, the establishment of working local government systems with active participation of the people, the development of a social service system that does not destroy the self-esteem and initiative of the individual, the emergence of a large middle class together with the development of a strong commercial structure, the reformation of the schools into units that educate free and responsible personalities and provide sufficient moral as well as scientific knowledge—all this requires guidance and models that still seem to be remote from the places where they are needed. The unconscious and half-conscious background within the people upon which a democratic system is being erected is different for the present

generation in the five new länder than it was in 1945 for the population of the three Western-occupied zones of Germany. Then, after twelve years of the Nazi regime, people still remembered how it had been before, and some leaders of the republican system who had experienced the Nazi time were still alive and ready to take over. When the GDR collapsed, the people there did not have much contact with a time 60 years ago. There is no "Eastern" Adenauer or Heuß. Instead of the Americans and British offering democratic concepts and systems, there are now West Germans imposing ready-made structures of democratic government. (If we speak with colleagues there, these things will only seldom be mentioned. It is, however, advisable to know of them.)

In collecting opinions among West Germans about the time needed for East Germany to catch up with the Western part, we get very different answers depending on whom we ask. Indeed, in this general form, the question is meaningless. The West German lawyer, thinking about the unacceptable form of Eastern jurisprudence, will arrive at a very high estimate, ten years or so. More or less convinced that no public life can function satisfactorily without a well-functioning legal system, he is prone to extend this estimate to all aspects of life in the new länder.

The West German scientist, remembering that the institutes in the East are in the turmoil of a sometimes radical reorganization, and having heard about the inadequate library service and the lack of modern instrumentation and computers, is more likely to arrive at estimates below five years, maybe three or even two. He may doubt whether a strong motivation and the practical possibility exist to reduce that time.

Looking for more substantial evidence, we arrive at a different result. Scientists from the GDR who managed to escape to the West generally had no problems in becoming fully accepted as equals by their collegues after a very short time. American scientists who traveled to the five new länder and visited research establishments in their own narrow scientific field often report that their colleagues there were fully up to Western standards. Sometimes they found that the problems under investigation were one or two years behind, but added that this gap will probably be quickly closed once all the restrictions have been removed.

Which restrictions still exist? Above all, many salaries are still much lower while many prices are higher (and others are increasing fast). Travel to the West is no longer forbidden, but it is still too expensive for the small budgets allotted to their institutes, in particular when considering the large catch-up needs. The scientists' ability to close still-existing gaps is essentially increased because of the special skills they had developed to overcome the severe restrictions they had lived with.

In the East, we have encountered the firm belief that the superiority of the West German institutes is not always as significant as had been claimed. We have also heard that some in the West express opinions that are not based on fact, even that they downgrade their Eastern colleagues for competition reasons.

Looking for a more quantitative approach to our question, we investigate a parallel question, namely how quickly can industry and the economy catch up (remembering that this region was higly industrialized before World War II). Here, we do not consider large companies where the differences between a relatively small number of enterprises can make a large difference for the whole; rather, we consider small and medium sized companies (of which there are many), which promises more reasonable statistics.

In West Germany, the Association of Owners of Independent Businesses (ASU) (Arbeitsgmeinschaft Selbständiger Unternehmer) has its headquarters in Bonn; its president is Volker Geers. The ASU has about 7000 members, and more than two-thirds of these have engaged themselves in the five new länder. More than 1100 companies responded to a series of questions, providing us with usable statistics. In 1991, 23 percent of these experienced an improvement over the year before; 19 percent reached stability. Thus, for 42 percent the specific crisis may have passed. Of the 58 percent who are still in debt, 38 are in the establishment process, and 20 percent expect a longer difficult period ahead. ("Der Scheinarbeit den Kampf angesagt," by Hans Martin Kölle, *Der Rheinische Merkur*, no. 51, p. 11, 20 December 1991, reports the numbers given here and provides

much more economic information. So does the other article quoted hereunder, on the same page.)

Some new companies are, indeed, already flourishing; yes, it has already happened that an East German company has bought a West German one. West Germany established a special bank (Kreditanstalt für Wiederaufbau) to help part of the development; by November 1991 it had already provided DM 24 billion, in almost 50,000 individual loans ("Die Progressiven Bundesländer," by Theo Mönch-Tegeder, *Der Rheinische Merkus*, no. 51, p. 11, 20 December 1991. We feel that our statement at the beginning of this chapter is sufficiently vindicated by these facts).

Opportunities and Recommendations

The general intellectual atmosphere in the new länder of the FRG is sometimes described as exciting and excited. The "excited" state also includes much bitterness and disappointments, but for the American visitor the impression of optimism prevails as far as we could observe. People are fully aware that they are confronted with a huge task, of a unique nature, with high potential and deep risks, for which no recipes are available. There is the possibility of a second "German Miracle," perhaps beginning in 1993 or 1994. Some interested foreign groups (especially from Europe and Asia) remember the first one. They are already active in the five new länder, especially in East Berlin (formerly the capital of the GDR, and the seat of many scientific institutes).

It is generally acknowledged that science is becoming so multifaceted that many institutes, even many countries, cannot afford to do the necessary research without collaboration. The potential of such collaboration, however, has not been fully evaluated. Some new ways may have to be sought, and, as our experience has taught us, can be found. In the following, we discuss only international interaction—with special emphasis on East Germany.

The first step is, of course, defining our own needs. For example, a researcher may recognize that analog problems may potentially be influencing his current work, even analog problems from a different discipline. He cannot solve them for several possible reasons, for example: no one in his laboratory has the special expertise to do it; he does not have the facilities needed; neither he nor his sponsor can afford it. In environmental sciences: the needed environment may not be available without collaboration with a foreign partner.

The second step of interaction may be to find a partner and to obtain some preliminary information—not only on the scientific capability of the potential partner but also on actual possibilities for international collaboration. Sometimes, the first part of this step is not difficult because partners may already be known from publications or former contacts; in other cases, especially with partners in Eastern countries including East Germany, this is not so. There, topics of research are shifting; publishing in Western journals as well as travels to Western institutes were and often still are restricted. The second part of this second step may be more difficult because we generally do not know the possibilities of foreign partners in international collaboration. We may be reluctant to approach a foreign partner without having at least some information on this point. His as well as our possibilities may be restricted or rather generous, including or excluding transfer of finances, researchers, or equipment. In most cases, additional knowledge will be desirable before a proposal for collaboration is initiated.

The third step, making contact with a potential partner, will often necessitate mutual visits. This can involve financial problems for one or both sides; some possibilities for support exist.

The fourth step may involve considerable difficulties: a decision on the legal form of collaboration, and, if necessary, the establishment of the legal framework. If such considerations can be excluded (as often will be possible), both sides will be spared a considerable amount of effort, problems alien to the average scientist, loss of time, and disappointments. There are, however, several legal frameworks for the cases where they are required.

This report (and our longer Report in three Parts) has been prepared to encourage and to facilitate interaction between American scientists and institutes and their counterparts in the Eastern parts of Germany. We provide information to implement the four steps discussed above. A few practical hints are given below.

When considering such cooperation, a specific European, especially German, fact must be remembered. In part because of the rather close relationship between government and research, information concerning ongoing research is extensively published in structured forms, sometimes even in the English language.

Practical Hints

How can this report (and our longer Report in three Parts) be practically used to establish desirable contacts? How can it help to learn where desirable contacts may be located? What additional hints can be given to reach beyond the limits of these reports, for example, more into the field of advanced development or industrial research?

At present, no reliable survey can be made on research being conducted at universities in East Germany. However, as pointed out, most research had been shifted from universities to institutes of the Academy by the former GDR. This deliberate process will take years to be reversed; all the while, research is going on in the reorganized institutes.

For a first approach to learn which research is being done, look into Part B. The institutes listed will significantly narrow the selection field. A further step involves looking into the work descriptions of the listed institutes. Thereafter, it becomes slightly more complicated because there are various sponsoring agencies and organizations. Each annually lists the research that it supports. Often, several such lists may have to be consulted. They are all available but some only with difficulties.

The Federal Ministry for Research and Technology annually edits the *Förder=Katalog*, which lists all individual projects that it supports. We found it in the German Embassy in Washington, DC, where the Science Attaché had a copy. It is a voluminous book, and we do not expect that copies can be freely given to individual researchers or institutes. But, it is a valuable resource to consult.

Additional and less voluminous sources are the annual reports of the Deutsche Forschungsgemeinschaft, the Max-Planck Society, and the Fraunhofer Society.

For work done at the institutes known as Groß-Forschungs-Einrichtungen (Large Research Institutions, National Research Laboratories), the Program-Budget of AGF (Arbeitsgemeinschaft der Großforschungs-einrichtungen), edited annually, discusses research and development topics in detail.

For work done in the Blue List Institutes as well as in institutes fully owned by a land government, the cognizant Standing Conference of Science Ministers in Bonn or the ministry of the land could be queried. A relatively new organization, the Working Association of Research Establishments of the Blue List (Arbeitsgmeinschaft Forschungs-Einrichtungen Blaue Liste) counted 67 of the 83 Blue List institutions among their members in July 1992; this number will probably grow.

Work conducted in institutes that belong to a federal ministry (Ressort-Forschungs-Einrichtungen) is supervised by the ministry, and information should generally be available from their annual reports.

Applied research and development done in independent institutes (especially for industry or small business; not described in our Reports) is known to the Working Association of Industrial Research Groups (Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von Guericke" eV, AIF), see above. A book edited by their Berlin office in 1991 lists 191 such institutes in East Germany alone and gives rather detailed descriptions.

In all cases, direct inquiries with the ministries or the headquarters of the organizations supporting research can be recommended; a kind response will almost always be received.

For obtaining information within the U.S., a new system is being established. The Library of Congress is collecting material containing this information provided by German sources and making it available to American institutes and scientists upon request. Contact:

John Feulner, Head
Technical Reports Section
Science and Technology Division (5583)
Library of Congress
Washington, DC, 20540
Phone: (202) 707-5664
Fax: (202) 707-1925.

It will take a few months before any substantial amount of material is there, and even longer

before any kind of completeness can be achieved. If an American scientist cannot come to the Library of Congress, the Technical Reports Section is basically willing to select material and copy it upon request. It would, however, be preferable to browse through the material in the Library of Congress. Mr. Feulner's collection is not expected to have papers or scientific reports of ongoing or completed research; instead it should be able to point to such reports, which may then be found in other parts of the Library of Congress.

Digital data banks of the same or similar type of information, in part on-line accessible, are discussed above.

CONCLUSIONS

This Report provides information on the structure and substance of research in the area of the former GDR, now usually referred to as the five new länder (plus East Berlin) of the FRG. We have included hints or more substantial information on the fact that many German organizations or agencies are interested in supporting international scientific collaboration. Often, the foreign partners are either developing nations or nations from the former East Bloc, but similar joint efforts do also exist with other Western nations including the U.S.

The authors have given related personal opinions here; with or without these, readers can draw their own conclusions from the information provided. The authors have also offered ideas on how the information can be used within the context of the American research effort. This outline of hypothetical possibilities is not meant to imply that chances for a positive interaction are just waiting to be realized. In spite of much rhetoric about international collaboration and in spite of many practical and successful attempts, a thorough investigation and analysis of potential possibilities and benefits does not yet seem to exist.

For scienctific research in the long run, both parties will obviously benefit from interaction, assuming that one-sided exploitation does not occur. Quite understandably, such fears have been expressed on both the American as well as the German side. A frank discussion of the possibilities is the best way to overcome obstacles of this kind. Examples such as the SAXON-FPN Experiment in 1989 indicate that this is possible.

The need for interaction is already visible, and it will increase. By beginning on a small scale and extending it through careful discussions and negotiations, advantages should become clearly evident for both sides. This will lead to realistic mutual benefits. One author (HD) has been involved in creating the SAXON-FPN experiment. Based on such experiences as well as from familiarity with individuals and conditions on both sides, we feel that ways exist that can lead to the positive results that all are looking for.

Appendix A

GENERAL INFORMATION ON GERMANY

The following publications may be helpful for visits to the FRG:

•*Facts about Germany* (published by the Presse- und Informations-Amt of the Federal Government in Bonn, Department IVA1, telephone +49 (228) 208-4110. The latest edition of this book includes the new länder. It can be obtained, free of charge, from the Presse-Referat of the German Embassy in Washington, DC, telephone: (202) 298-4251. This book provides detailed information on the country, people, history; state, politics, the law, economics, society, welfare, leisure, education, science, culture. There is a bibliography and an index. More than 400 pages; many diagrams and pictures in color. In English.

•*These Strange German Ways* (published by Atlantik-Brücke e.V., in their Hamburg office, request by telephone +49 (40) 59-66-18; 16th edition, 135 pp, $3.00 (volume discounts available). This is an entertaining guide to German facilities, customs,

and traditions, written to help visitors from overseas feel comfortable when traveling in the FRG. In English.

•*Meet United Germany, Perspectives* (both published by Frankfurter Allgemeine Zeitung, Information Services, and the Atlantik-Brücke, 1991, 280 pp). Approximate price (for both volumes, see below) is DM 50. Available from:

Frankfurter Allgemeine Zeitung
Informationsdienste
Hellerhof Straße 2-4
D/W-6000 Frankfurt / Main 1.

Perspectives is described in its introduction as follows: "The book contains 22 chapters on a wide range of topics from the recent history of Germany divided to the future foreign policy of Germany united. Each chapter, complete in itself, has been written by an expert in the field; many of the authors are themselves in influential positions and indeed, some are key players in the shaping of the new Germany. Others are professional observers with years of Germany-watching experience. Thus, all of the contributions are highly individual blends of the objective and the subjective. The whole is a mosaic, a colorful picture of a country in a particular colourful phase of its history."

•*Meet United Germany, Handbook 1991/92* (published by Frankfurter Allgemeine Zeitung, Information Services, and the Atlantik-Brücke, 1991, 184 pp.) Approximate price (for both volumes, see above) is DM 50. Available from:

Frankfurter Allgemeine Zeitung
Informationsdienste
Hellerhof Straße 2-4
D/W-6000 Frankfurt / Main 1.

The volume *Handbook 1991/92* is described in the introduction to volume *Perspectives* as: "*Handbook 1991/92* is a compilation of up-to-date useful information for those intending to visit the FRG on business. It covers everything from the banking system to the most recent changes in corporate and personal taxation; from an overview of the most important industries to a run-down of the FRG's top 100 companies; from a property report to incentives to invest in the new länder. It contains a section on transportation, as well as portraits of the individual länder and the most important cities. It also provides valuable sources and pointers for those seeking more detailed information in specific areas."

•*Taschenbuch des Öffentlichen Lebens, Deutschland, 1991/1992* by Albert Oeckl (41st edition; published by Festland Verlag, Basteistr. 88, D/W-5300 Bonn 2, telephone: +49 (0228) 36-20-21; 1452 pages) provides information on all branches of public life in the FRG, names, addresses and telephone numbers, often with brief descriptions. The index contains 10,000 organizations and agencies, the name index lists 17,000 persons. In German, price about DM 110. There are similar but much smaller editions for individual länder.

•Articles by Marc Fisher in *The Washington Post.* Marc Fisher is Chief of the Berlin Bureau of *The Washington Post*, moving there from Bonn in 1991. Probably in part because of his academic training as a historian, Fisher is able to avoid pitfalls of journalism. In the opinion of the authors of this Report, his artices are full of insight and awareness of the general and many special situations; they are fundamentally critical and eminently readable. For Americans intending to make business trips to or work in Germany, we recommend, especially, "Deutsche Doze. The Leisurely Lives of the Germany's Worker Bees," *The Washington Post*, 115:150:C1/C4; 3 May 1992. The article deals with attitudes of Germans toward work and leisure. In the same issue, on p. F1/F8 we find Fisher's article "East Side Story. Meet the Hotz Family, They Went to West Germany to Taste Freedom. And Found a Bitter Pill."

Appendix B

HINTS FOR TRAVELING IN EAST GERMANY

Names of towns, streets, organizations, and institutions have been changed in the last two years. This process continues. Few institutes have chosen an "official" English translation for their name; several ad hoc translations of the same name may give different results and thereby create confusion. In the present report, we use both English and German names. That may help clarity, it also may help correspondence. Contrary to the situation in the Western länder of the FRG, the knowledge of English is less common in the Eastern länder. There, all had to study Russian. A few had English in school, some—mainly scientists—learned English on their own.

When planning a trip, some potential difficulties should be kept in mind. Planning for cross-country travel by car may involve long detours because of road repair work. The detours are not always clearly marked; "getting lost" is a frequent experience. There can be long distances between filling stations. Trains may be late; again, repair work is often the cause.

It is especially important to make very early hotel reservations (months, in particular, for weekends). This is necessary but not always easy because of poor telephone connections (now being replaced as fast as possible). When there, we learned of a West German travel agency that claims to be expert in handling hotel reservations in the five new länder. Telephone discussions with them gave the impression of efficiency, but we do not have any personal experience with their reservation services:

Hotel Reservation Service
Drusus Gasse 7 - 11
D/W-5000 Köln 1
Germany
Phone: +49 (221) 2077-0
Fax: +49 (221) 2077-666
Telex: 8881151 hrs d
Direct e-mail from U.S. ("Videotex"): in preparation.

It may be difficult to locate specific addresses in the cities; maps may show names that have since been replaced, or addresses may refer to old names that are not found on new maps. We encountered all these difficulties; however, local people proved most helpful. Maps from the GDR times usually have no scales.

There are also problems with the telephone system. The system of the GDR was not very effective. After reunification, the West German Telekom preferred to install new lines (of a very modern type) instead of trying to completely overhaul the old system. That is progressing quickly, at first trying to serve the economic community; but it may take a few more years before a complete improvement is seen. A second problem is that the system of town codes in both parts of Germany were set up independently of each other. The results have been that the same town code occurred for both a West- and an East German town. Therefore, the town codes in the five new länder had to be changed; they now all begin with 03 or 3, as the case may be (West Germany had not used town codes beginning with 03 or 3). Another point may be of help when using the telephone: both in West and in East Germany, the number of digits in a local telephone number varies, from maybe only two (in a little village) to many, and they are usually written without a hyphen between digits. If, in official telephone books, etc., a hyphen appears with a 0, 1, or 01 behind it, this indicates that the number is that of an agency, corporation, or company, and the 0, 1, or 01 connects the caller to a switchboard. If the caller knows the desired extension, the 0, 1 or 01 may be replaced by that extension (so-called "Durchwahl"-direct dialing).

A similar (and still unsolved) problem exists with the postal ZIP codes: the basics are different. In West Germany, one ZIP code is valid for a whole town, even for a large one, so postal zones must be used in addition (written after the name of

the town). In the GDR, the postal zones were incorporated into the ZIP codes, so each ZIP code there is valid only for one part of a big town. After reunification, it was proposed to precede a West German ZIP code with a W, and East German one with an O. In this Report we followed that proposal, but in Germany, the W is often omitted, and only the O is used. The correct way for international mail is to precede the ZIP code first with a D for Germany (Deutschland) and then, after a slash (/) with a W or an O, hyphen (-), ZIP code, name of town (and in West Germany, postal zone if applicable). ZIP code systems will be unified for both parts of Germany as soon as possible. This means new numbers for everyone in the reunified Germany.

As a side-remark: the same kind of problem exists for the numbering systems for streets, but it is a smaller problem. In most cases, the numbers that had been introduced before World War II, in both parts of Germany, were continued. The analog problem for railroad lines (e.g., in time tables) has been solved by introducing new numbers throughout all parts of Germany in May 1992.

Appendix C

TITLES AND RANKS OF GERMAN CIVIL SERVANTS AND ACADEMICS

Civil Servants

In federal government as well as in länder governments, civil servants have job titles that are used in written material and can be used, especially when a new contact is made, in oral address as well. They precede any academic title, e.g., Ministerialrat Dr. H. A. Müller. Sometimes, attempts are made to compare these titles with military ranks, but there is no official connection. Any private connection is bound to be imprecise, in part because the real position of a civil servant depends not only on his title but also on his job.

The uppermost civil servant in a German ministry [except the Minister him- (or her-) self] is a Staatssekretär. There may be one or a few, directly under the minister.

Academic Titles

We are not dealing with the names of *positions* or *jobs* in the German academic or scientific environment. They are complicated and have changed several times recently. In our communications they are probably of lesser interest than the *personal academic* titles.

In the German environment, personal titles are more often given and used than in the American environment. Academic titles are given by universities and other schools on the same level (e.g., technical universities, "Technische Hochschulen") and are given to anyone who has passed the 12 years of German school and finished it with a "Reifezeugnis" (also called Abitur); others can be conferred under certain conditions. After completion of a full study, a title that begins with Dipl. (Diplom) can be acquired by a written thesis and an examanation. Most often it appears as Dipl.Ing. (Diplom-Ingenieur), but there are many others, e.g., Dipl.Phys. or Dipl.Met. for a physicist or meteorologist, respectively. [Not long ago, colleges of a somewhat lower level (accessible after fewer years at school), which formerly provided the title Ingenieur, now also have the right to give the title Diplom-Ingenieur (whereupon some Dipl.-Ing's of a Technical University added a (TH) or something similar to their title).] Medical schools do not give a Diplom-title.

The Dipl. title is always used in written address but is generally not used orally. It is considered to be equivalent to an American Master's degree.

Except for medical or dental careers (and perhaps a few others), the Dipl.- title is a normal pre-condition for the admission to a Doctor's degree pursuit. In their requirements, the Doctor's degrees are similar to the American ones but they are written differently. This title always begins

with a "Dr." which is followed by an abbreviation of the Latin description of the scientific branch, for example:

Dr.phil. - (philosophy and other humanities)
Dr.rer.nat. or Dr.sci.nat. - (natural sciences)
Dr.iur. - (jurisprudence)
Dr.med. - (medicine)
Dr.med.dent. - (dentistry) and so on, but

Dr.-Ing. for Doctor-Engineer, which many think is more difficult to acquire than other doctoral degrees.

The routine way to become a university professor in Germany was the "Habilitation," which required another thesis and a formal lecture before a critical audience. This is still true. In the past 60 years, those who have passed the Habilitation have the right to add the word "habil." to their doctor's title. In written address, the full doctor's title is used, plus the "Herr" or "Frau," for example: Herr Dr.iur.W.Müller or Frau Dr.rer.nat. habil.G.Lehmann. If the person is appointed a professor, the doctor's titles are still added: Herr Prof.Dr.med.habil.S.Schmidt.

In a report of a meeting, if a person is quoted more than once, the full title is used only for the first quotation. Of course, in scientific references, etc., no title is used.

Orally, the expression is much shorter: Herr Doktor Müller, Frau Doktor Lehmann, Herr Professor Schmidt.

Military officers with an academic title use it after their military rank, e.g., Herr Kapitän zur See Dr. Schröder, for a Navy captain with a doctor's degree. Aristocratic titles still exist in Germany; they are combined with academic ones, e.g., Frau Dr. Marion Gräfin Dornburg.

Formerly, all German universities were led by a Rektor. This person was one of the leading professors of that university and was elected Rektor for a period of one or a few years. In this office, he had the additional title "Magnifizenz" (with some complicated rules for addressing him attached). Use of this title has declined in this century, but it is again being applied at some universities in East Germany (but without the complicated rules). Some West German universities disestablished the position of Rektor and applied a President system similar to the American one. (The information given here is not valid for Austria or Switzerland.)

Materials

Metrology and Research at the National Physical Laboratory, Teddington, U.K.

by Joseph H. Magill, Liaison Scientist for Polymeric Materials for the Office of Naval Research, European Office. Dr. Magill joined ONR Europe from the University of Pittsburgh, Pennsylvania, where he held Professorships jointly in Materials Science and Engineering and in Chemical and Petroleum Engineering.

KEYWORDS: metrology, polymers, composites, thermal properties, mechanical properties

INTRODUCTION

The National Physical Laboratory (NPL) at Teddington, Middlesex, U.K., was established in 1900 as a "prestigious facility of Britain." Its Division of Materials Metrology houses the Polymer Research and Testing Facility. Since 1990 NPL has been a government agency "standing on its own feet financially and driven by financial targets set by the board of Trade." At present it is

undergoing a £60 million building expansion. Its director, Dr. Peter Clapham, prides himself that scientists at this academic and practical laboratory "have taken to the idea that their research is of no more value than they can persuade their sponsors it is."

Figure 1 shows the organizational structure of NPL. The polymer components of the facility are located in the Division of Material Metrology, whose Head for Composites and Polymer Properties is Dr. I.R. Sced. Several key research personnel in this division have polymer interests in areas of

- creep measurement and modelling;
- impact properties;
- stress and deformation analysis;• dynamic stiffness and damping;
- structure and properties;
- polymer composites, modeling;
- mechanical properties testing (including sonic testing);
- high-temperature testing; and
- surface spectroscopy,

which are of interest and importance to the Office of Naval Research.

The NPL facility has a network of links with European and international laboratories. They also work in association with a large number of industrial organizations.[1]

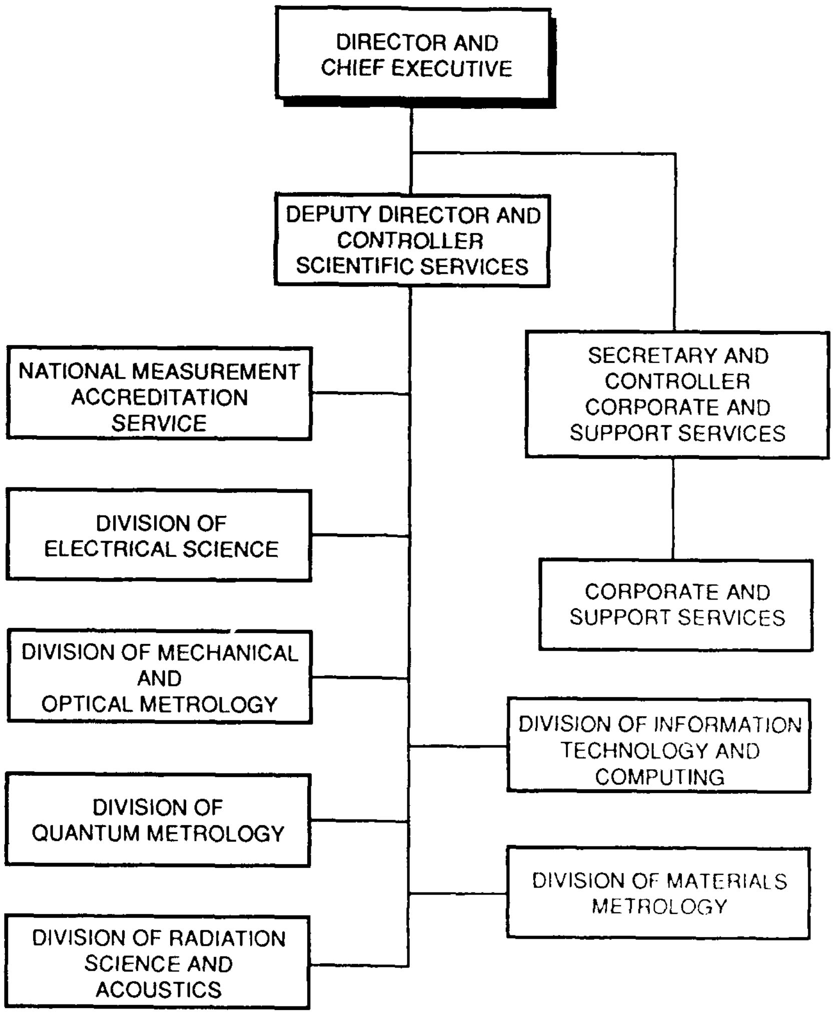


Fig. 1—NPS organizational structure

STRUCTURE AND PROPERTIES

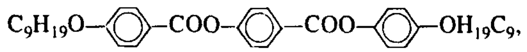
Thermal Measurements

Since processing affects polymer morphology and properties it is necessary to characterize these parameters and to determine how they influence processing variables. At NPL, Dr. M.J. Richardson and co-workers are involved in measurement methods that provide meaningful information on process-related aspects of cure, crystallinity, orientation, and glass formation for

- materials evaluation;
- quality assurance and creditation; and
- fundamental understanding of property-structure relationships.

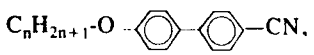
Many ongoing areas of investigation deal with these topics, which include polymers, copolymers, blends of nonpolymeric and polymeric mesophases, and network resins. Some of the topics being dealt with are:

- Nonpolymeric liquid crystals like

  which give rise to some puzzling aging transitions as well as mesophase transitions. The multiple peaks and their intensity below the mesophase range are a function of *t* and *T*, but their behavior with variations in aging is not yet understood. This work is being conducted in collaboration with Dr. Gunther Höhne (University of Ulm, Germany).

- The cyanobiphenyls:

  where C_n ranges between 1 and 12 are under investigation. These materials were obtained from Professor Emeritus A. Grey (University of Hull). One of the basic thrusts of this investigation is to construct free-energy diagrams in the dynamic measurement mode (DSC) for selected materials systems.

- The curing of epoxy resin—monitoring the heat of cure by DSC. The literature contains several publications in this area, particularly for relatively fast reactive injection molding processes (RIM). RIM is an important and growing industrial polymerization processing technique for the in situ formation of final plastics components from monomeric ingredients with considerable savings in energy and time. The fundamental assessment of the reaction kinetics in such cases needs to be properly understood (and evaluated)

- A little more esoteric is an ongoing project in collaboration with Dr. Colin Booth (University of Manchester) dealing with well-characterized ethylene oxide oligomers. Research on the crystallization of these monodisperse oligomers is a long-standing project that is nearing completion. Some small samples of

  $$HO\{CH_2CH_2O\}_xOH,$$

  where x is an integer (as high as 45) have been examined in detail to perform a Flory-Vrij' type (F-V) analysis[2] of the kind that has been done for short-chain paraffin fractions. Unfortunately, this system is complicated by the presence of H-bonded end groups on the oligomers; this complicates the physical parameters of the oligomers through chemical association. Still, in a fundamental sense, the investigation may eventually provide melting and other thermodynamic enthalpic parameters equivalent to those now available for polyethylene.

- Again at the fundamental level but with practical implications, is the general investigation of glass formation in materials. Several theories[3-6] in the literature provide varying and sometimes debatable significance when they are tested or evaluated against rigorous experiments.

- On the metrology side, the International Compiled Thermal Analysis (ICTA) is connected with standards for DSC studies, particularly in regard to the temperature and entropy for calibrants such as indium and alumina where heat transfer and thermal resistance of the sample-sensor are different.

This is certainly also the case for most polymeric materials whenever quality measurements are required. Again, in purity determination made by DSC there are calibration problems, even between instruments of the same manufacturer (e.g., the new DSC7 and older DSC2, both Perkin-Elmer instruments). The DSC7 instrument is now being evaluated by Richardson et al. It is absolutely imperative that quality assurance in instrumentation be universal for the proper evaluation of materials. Calibration problems should be appreciated and surmounted, and instrument manufacturers must be aware of all the complications that can arise in materials evaluation when using their equipment. Round-robin testing is an inherent and important evaluation procedure for materials and instruments. In collaboration with other institutions (academic and industrial) under the auspices of NPL and IUPAC, ongoing tests are in progress for users of quality control instruments for materials property assessments.

- Another significant program[7] at NPL (in collaboration with Dr. J. Stejny, University of Bristol) is associated with CR-39 glass forming network systems and their specific heat C_p temperature dependence measured by DSC. These polymers, which can be used as radon and radiation detectors, are based on polymerized glycol bis-(allyl carbonate)[8] monomer, the polymer chemistry and physics of which have been reported.

- In the biomedical field, Dr. Richardson and coworkers[9] have studied skin tissue/carcinogenious tumors by using DSC-simulated materials to represent the heat capacity history of these human moieties for standard reference purposes. A publication on this topic is in progress, coauthored with Dr. Robinson et al. Of course, materials need standardization, and the Metrology Department of NPL caters to this, both nationally and internationally.

Mechanical Property Studies

Dr. Brian E. Read and associates[10-12] are concerned with several important aspects of mechanical property measurement and evaluation. Of considerable importance is creep modeling[10] from the viewpoints of

- storage time effects in physical aging of polymers;
- physical aging during creep itself; and
- the influence of material anisotropy for establishing an upper and lower bound on material behavior.

Aside from monitoring and predicting the behavior of plastics (crystalline and amorphous), consideration is being given to establishing a test protocol for the preparation and evaluation of polymers in collaboration with other institutions such as the British Plastics Federation (BPF) and others. NPL/BPF work has been incorporated into some British Standard Specifications.

In the writer's opinion, insufficient attention has been devoted to the development of models for predicting long-term creep deformation in polymers, particularly at different temperature and stress levels with the aid of extensive laboratory (usually short-term) tests. For several years now this short-coming has been appreciated by Dr. Read and coworkers.[12] They have determined the creep compliance distribution curves of amorphous as well as crystalline commercial polymers that can be extended 8 to 10 decades of time, mostly at room temperature (Fig. 2).

The influence of creep rate on material changes with temperature have also been investigated. The key information and significant property predictions for engineering applications are based primarily on modeling short- and long-time relaxation processes, especially

- the secondary relaxation (β) process, and
- the glass-rubber (γ) process(es).

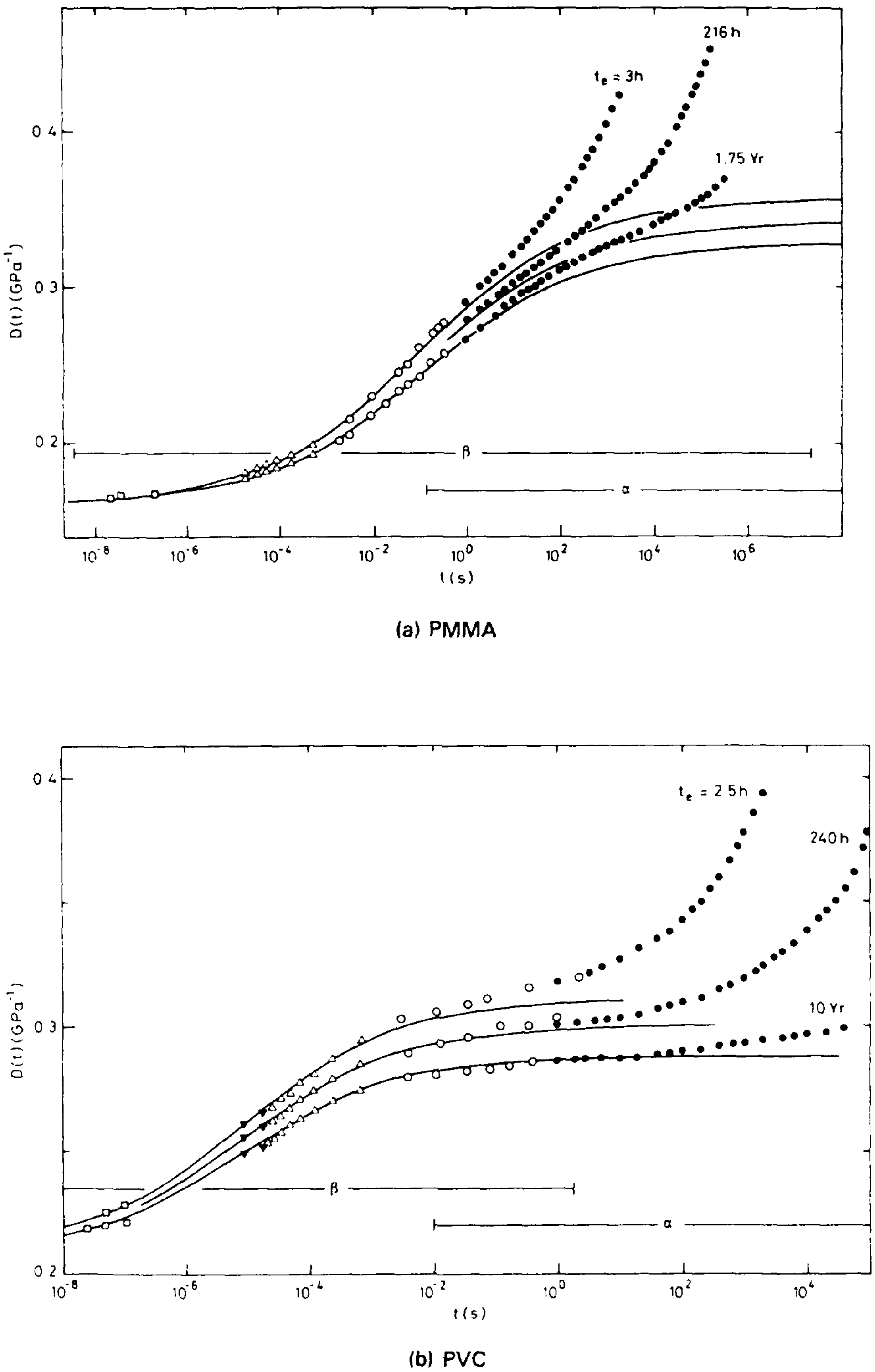
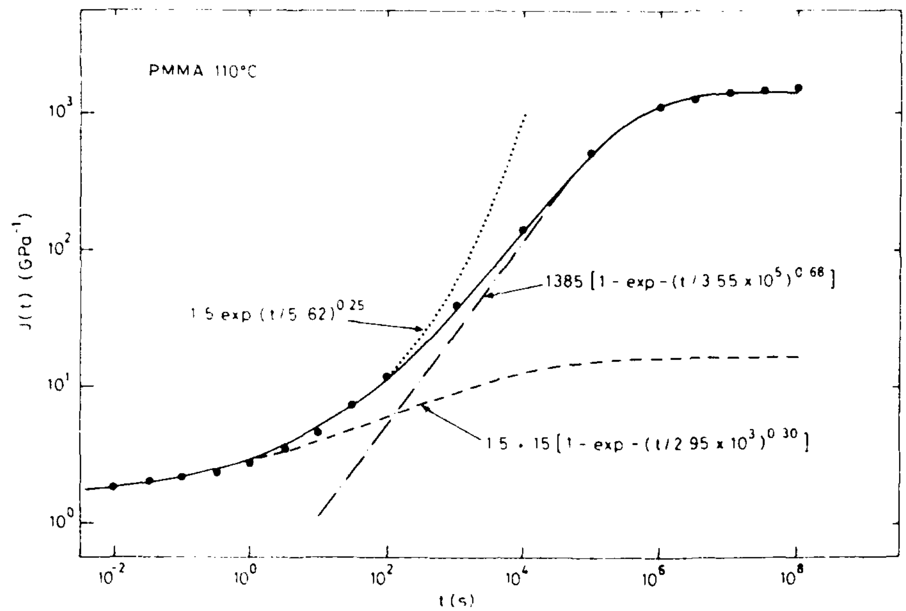


Fig. 2—Creep curves $D(T)$ for polymers that have been selectively aged at times indicated on each curve. (*Journal of Non-crystalline Solids*, used by permission)



(......Struik-Kohlraush functions; ------Williams-Watts functions)

Fig. 3—Compiled double-logarithmic plots of shear compliance J(t) vs time (Journal of Non-crystalline Solids, used by permission)

For the β contribution, Cole-Cole type equations provide a satisfactory representation of the data. For the long-time γ contribution, the Williams-Watt or Struik-Kohhrausch equation is used to represent the data. Typical representations are shown in Fig. 3. Since the intricate details of some of this work are in the literature, it is not necessary to dwell on modeling procedures at this point.

However, important discoveries should be emphasized, namely, that:

- there is complex interplay between creep (relaxation) and the molecular morphology at the local level in the polymer; and
- there are significant behavioral differences between amorphous and crystalline materials.

Physical aging invariably produces a decrease in the β process and an increase in the retardation time for the α-process with unchanged width in the distributions. Long-term predictions are possible. Slow aging (attributed to rearrangements in the solid) and improved material stiffness occurs as the material densifies under these conditions. Stress (applied to the material) rejuvenates the material. Increasing the environmental temperature (still below 100°C usually) followed by measurements causes enhanced creep that is attributed to molecular mobilization. There is not universal agreement on this process, including the mechanism of property-morphology details between the models of Struik, McKenna, Read, and others. According to Read and coworkers, aging in polypropylene at room temperature is controlled by the γ-process.

Matrix Composites, Modeling, and Metrology

Dr. Bryan Roebuck and coworkers[13,14] have examined the problems associated with fracture toughness test methods for both fiber- and particulate-reinforced metal matrix composites (MMC), variously dispersed. Roebuck points out that there is a need to set priorities for the development of test procedures to assess component failure. Of course, this can be tackled only if a firm understanding of failure mechanism per se is known, including inherent stresses in the material. The relative merits of crack initiation and damage development must be assessed with respect to one

another to gain a better understanding of these processes that have a high priority and must be critically evaluated. Crack shapes in relation to toughness fracture in thick specimens containing SiC particulates-reinforced metal composites have been analyzed. These analyses are based on a simplified model that (until now) ignores the difficulties associated with variations in the stress intensity factor *K*, especially where crack fronts are highly curved. This pragmatic "solution" for dealing with the problem must await improved ways to calculate or model by computer, homogeneous and/or heterogenous properties of MMC. This approach is now being used.

Dr. Brian F. Dyson[15,16] has been investigating techniques for improving measurements and modeling of strain softening alloys. The synergy between creep life and stress-induced corrosion effects were addressed, and the model has been validated for Cr Mo V steel. Creep damage categories and mechanisms have been elaborated in a framework of continuous damage mechanics. Design and predictions using parallel computing procedures (made in collaboration with the University of Cambridge) will evolve more usefully over the new few years for this purpose. For Ni-based alloys at high temperature, failure is often attributed correctly to creep and then to fracture, even though this is sometimes obscured. The biggest constraint in design and in analysis is limited by the availability of useful constitutive equations for describing deformation. Dyson's objective is to improve measurement techniques for mechanical behavior at high temperatures and to predict behavior under a plethora of imposed service conditions. Damage mechanism are categorized to be of eight types, one dominant or common feature being rate of stress with time. The important influence of aggressive environments must be decoupled from the test in the material evaluation.

In the polymers field, the policy of the Division of Materials Metrology is now emphasizing work in quality thermoset materials, which are becoming increasingly important for industry, apart from thermoplastics that are well established. The basis of the proposed work (supported by Ford Motor Company, BIP Chemicals, and many small companies) is to investigate the effect of processing variables on properties, particularly for polyesters and phenolics. The development of test methods and the characterization of molding conditions and concomitant properties produced are the remit of NPL. Properties, or rather parameters such as melt flow index now in use by industry, are considered to be a poor guide to processing plastics when it is viscosity that should be measured over a range of conditions. Special equipment, in association with Carter Baker Industries, has been built for the on-line assessment of processing property behavior of industrially used plastics.

Process modeling too is also being investigated, in collaboration with selected U.K. universities. Round-robin testing on an international scale now figures in the development of any ISO standard for cure in thermosets, for example. In like manner, a modified ISO standard for surface quality has been developed, and attention is being given to the role and control of fiber fillers in molding operations. The characterization and calculation of anisotropic moduli and strength also feature. Again in collaboration with U.K. universities, measurements of residual stress distributions throughout molding operation are of some concern because inherent stresses can be detrimental to material properties as they change with time. Consequently a clear understanding of the aging of the plastics and the development of ways to monitor or predict this behavior under various environmental conditions is a necessary component of the materials measurements program at NPL.

The research described here is supported by industrial contributions; there is also an extra payoff in that opportunities for marketing newly developed equipment may also materialize from it. The work is competitive and provides a basis for designing plastic components.

Dr. Graham Simms et al.[17-19] have long been involved with developing standard test methods, particularly for fiber/polymer composites. Tests carried out according to the British Standards Institute (BSI), Comite-Européan de Normalization (CEN), Japanese Institute Standards (JIS), and the International Standards Organization (ISO) now require that they be reconciled under a European Community (EC) Test umbrella called the Versailles Project on Advanced Materials and Standards (VAMAS), which is a seven-country agreement. To the NPL metrology laboratory, standards must be evaluated because of the mandatory nature of the pending single European market. At

this time, some existing standards may need to be withdrawn in the face of new EC requirements. At the present time, the potential for harmonization is now fairly well established through design standards and working test groups that must continue to develop initiatives and promote contacts with trade bodies and standards organization in a consortium-funded projects.

Specific tests for composites must be in line with design analysis procedures for assessing flexure, tension, and combined flexure, as well as tension stiffness and strength properties of reinforced plastics composites. Failure by local buckling as well as materials failure per se receives much attention at the metrology laboratory and U.K. industries. Charpy impact testing figures prominently in quality and safety control of materials—generally when they are used in demanding applications (for example, in pressure vessels, bridges, and off-shore structures). Reference standards are also extremely important for verifying test machines for certification.

Ultrasonic measurements of elastic moduli of anisotropic materials is a key concern of Dr. Gregory Dean and Ken Thomas. Much of the equipment is developed in the metrology laboratory; procedures are always being developed and revised for different classes of materials that come under the scrutiny of industry and the department as well as the international bodies or working parties. Frequently there is a strong "tie-in" with the work of Drs. Richardson and Read mentioned elsewhere in this article. With the advent of quality AL/SiC fibers and C fibers as well as improvements in traditional and newly developed plastics, standard test procedures have and are being developed.

Composites (metal, ceramic and polymeric) feature in the NPL investigations, using theoretical and experimental approaches. In all of these engineering materials, the need for sound and widely recommended procedures to provide reliable and relevant tests in application is greatly appreciated. Consequently, assessments have been made of composites particularly in the measurements and modeling of mechanical properties. Accordingly, property requirements and reliability standards must be met, and testing codes must be developed/modified. Accurate strain and tensile measurements are obviously of primary importance, and the goal must be to address the demanding needs for materials in our time. To this end, reports of several NPL investigators are appropriate.

The theoretical work of Dr. L. Neil McCartney[20-23] is very evident in a new theory developed recently for stress transfer between fiber and matrix in unidirectional composites that have matrix cracks and/or broken fibers. More extensive developments have taken place in McCartney's investigations, especially where fiber-reinforced cross-ply laminates are involved. Attention in modeling composites now considers situations that take into account temperature-dependent yield and work-hardening and can estimate residual inherent stresses in material following their manufacture. Nonlinear stress-strain curves are involved and lead to differing behaviors in tension and compression.

NANOMETROLOGY

Nanometrology is also a key activity at NPL and involves interactions with other institutions. Measurements down to the atomic scale have been made by using scanning tunneling and atomic force microscopes (STM and AFM, respectively). Industry now demands key precision in machining, positioning, and control of dimensions almost commensurate with the atom. Compact disk technology, laser style profilometry, microelectronics in the manufacture of quantum well devices, and the "key and lock" principle of proteins in nature are now used for the development of designer molecules in the laboratory.

OTHER ACTIVITIES

There are many more scientific activities associated with the NPL laboratories, but this article is mainly concerned with polymeric or polymer-related work. Technology transfer links many important institutions with government departments, including

- manufacturing companies,
- national and international standards committees and organizations,
- national research laboratories,
- service industries, and
- universities and polytechnical institutes where metrological investigations are at the frontiers of science.

SUMMARY

The NPL complex of laboratories has diverse interests, well beyond those documented briefly in this article. The Division of Materials, Standards and Data has a preeminent position in the science and metrology field. Modern materials and their evaluation, including measurement-related and exploratory research provides a framework for understanding the relationships between structure, processing, and performance of materials as well as accuracy levels needed for engineering design and control. In its new role as an executive agency of the Department of Trade and Industry, its responsibility in the U.K. deals with underpinning work in materials property measurement and data evaluation. This responsibility will grow as standardization requirements increase in significance as the U.K. joins with the EC in a future "United States of Europe."

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The Pulsed High Magnetic Field Facility, Toulouse, France

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KEYWORDS: semiconductors; magnetoresistance; superconductivity; far infrared; fluctuation theory

INTRODUCTION

Le Service National des Champs Magnetiques Pulses (SNCMP) is a dynamic research center devoted to the study of physical properties of matter in large magnetic fields. This laboratory, established in 1973 and fully operational by 1976, differs from many others in that the magnetic fields are pulsed. This unique service supports a wide range of research activities and draws scientific collaborators from all over the world.

Le Service is nestled unobtrusively in a modest building on the campus of the Institut National des Sciences Appliquees (INSA) and the Universite

Paul Sabatier, which are only a few kilometers outside of Toulouse. Often referred to as the Ville Rose because of its Mediterranean-style walls of red brick and the red tile roofs that cap its buildings, Toulouse has become the center of the French aerospace industry.

Le Service National des Champs Magnetiques Pulses is part of the INSA and L'Universite Paul Sabatier (UPS). It belongs to the CNRS (Centre National de la Recherche Scientifique) that, together with the DRED (Direction de la Recherche et des Etudes Doctorales du Ministere de l'Education Nationale), provide the funding. The two-story building of the SNCMP provides offices for professors and students, laboratory space for investigations, and a small machine shop for technicians. Pulsed magnetic fields are provided at five stations positioned on the upper floor of the building. Four of the stations are instrumented for transport and magnetization experiments, while the fifth supportsmagneto-optic experiments in the infrared. The sixth station is dedicated to research on new coils. Cryostats are inserted into the bore of the solenoids to vary the sample temperature from 1.5 K to room temperature. A new apparatus using a^{3}He-^{4}He *dilution refrigerator, which can cool to* temperatures as low as 0.05 K in pulsed magnetic fields as large as 42 T, has recently been added.

The heart of each station is a reinforced copper solenoid used to generate the pulsed magnetic field. Each solenoid is immersed in a bath of liquid nitrogen that can be pumped to temperatures as low as 63 K. A large bank of capacitors (they occupy roughly one-quarter of the basement and weigh nearly 14 tons!) stores 1.25 MJ of electrical energy when charged to full voltage. Discharge of this energy into one of the 46 T coils generates a current pulse that reaches a maximum value of approximately 5,000 Å in 80 to 100 ms and then decays in roughly 1 second. Figure 1 is a typical profile of the magnetic field as a function of time. Within this short period of time, all of the data for a given measurement are taken with a fast digitizing circuit that takes 16-bit data points at a rate of 200,000 measurements per second. To convey some appreciation for the sophistication and capability of the method, Fig. 2 shows a portion of a susceptibility scan (between 40 and 50 tesla) of a Pt single crystal which shows the de Haas-van Alphen oscillations of the electrons following orbits along the contours of the Fermi surface (FS). Similar measurements for Au (a simpler and well understood FS) agree well with the results taken *with* dc fields available at other facilities, thus confirming the validity of the technique. At the higher fields attainable at the SNCMP, higher

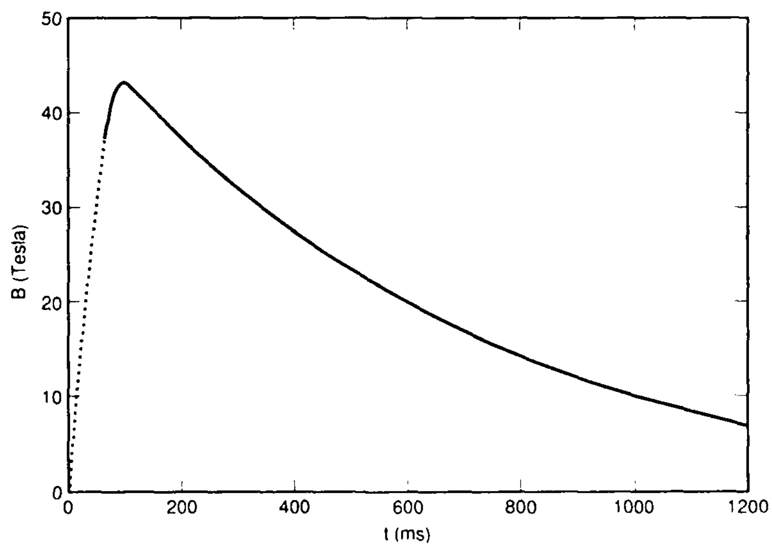

Fig. 1 —Typical profile of the pulsed magnetic field as a function of time

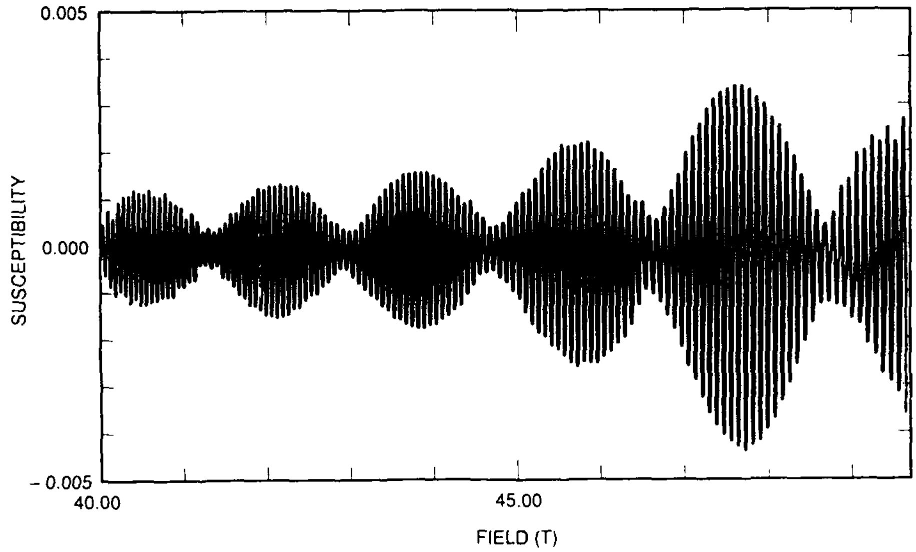

Fig. 2—de Haas-van Alphen oscillations in the magnetic susceptibility of a Pt single crystal [110] orientation]

frequency oscillations corresponding to larger orbits on a different part of the FS ("belly orbits") are superimposed on the low-frequency oscillations. Figure 3 shows these plotted versus 1/H.

Depending on the solenoid design, maximum magnetic fields from 40 to 61 T are generated. The mechanical stresses generated in the solenoids are heroic: at peak current, a pressure of 5 tons/cm^2 is generated in the restraining band that surrounds each coil. Deformation of the coil windings due to such forces ultimately takes its toll: on average, after 150 cycles, the windings of a 53 T coil loosen and move sufficiently to introduce noise. This noise renders the coils useless for the most exacting experiments (e.g., de Haas-van Alphen), but others (e.g., transport) can still be carried out. Ultimately, however, the coils fail as the result of the repeated stress; extending the life of the solenoids is one of the ongoing research activities of the laboratory. Table 1 summarizes characteristics of the solenoids used at the laboratory.

RESEARCH ACTIVITIES

A wide range of experiments are conducted by the resident research staff who are either members of the Laboratoire de Physique des Solides at Toulouse or on the staff of the CNRS. Investigators from other institutions also visit the facility to collaborate with the staff. Research initially emphasized the properties of semiconductors in a magnetic field, but activities have expanded to include metals, organic conductors, magnetic insulators, and superconductors.

Present research activities and interests of the laboratory are briefly described below.

Low-Dimensional Conductors

What are the properties of 1- and 2-dimensional materials in high magnetic fields? During the last ten years, Jean Pierre Ulmet and his collaborators, Alain Audouard and Luc Brossard, have studied the magneto-resistance, Hall effect, and Shubnikov-de Haas effect in such materials in search of answers. From this rich area of research, we select only a few examples of some of the conclusions which have been reached.

$NbSe_3$: This quasi-1-D material remains conducting to absolute zero despite the fact that it undergoes two charge-density transitions. The magnetoresistance R(H,T) of this material was found to undergo a series of oscillations as a function of magnetic field.[1] Data taken at other laboratories equipped with dc magnetic fields as large as

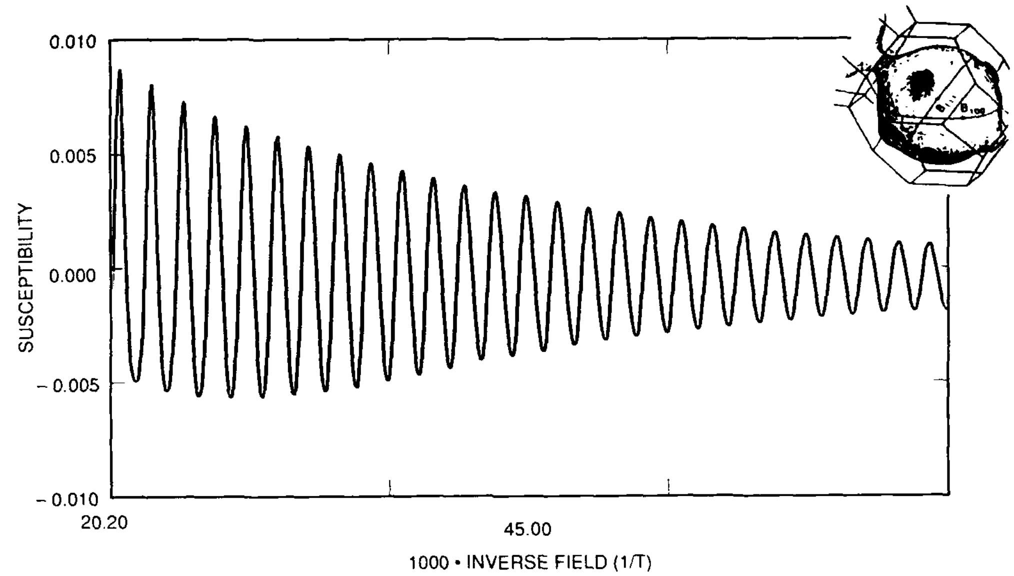

Fig. 3—Magnetic susceptibility of gold as a function of the inverse magnetic field H, higher frequency oscillations corresponding to larger orbits on a different part of the Fermi surface ("belly orbits") are superimposed on the low-frequency ("neck orbits") oscillations.

Table 1. Magnet Characteristics

Maximum field (T)	43	46	61
Stored energy (MJ)	1.25	1.25	1.25
Usable inner diameter at liquid He temperatures (mm)	20	6	6
Inhomogeneity in 10 mm	6×10^{-4}	6×10^{-4}	6×10^{-3}
Rise time (ms)	80 and 100	80	40
Decay time (s)	0.8	0.8	0.25

25 T fall short, however, of reaching a sufficiently large field to decide between two explanations: magnetic breakdown, or Shubnin-kov-de Haas (S-dH) oscillations (i.e., R increases whenever the cyclotron condition $h\omega = eH/m^*c$, where m^* is the effective mass, is satisfied as carriers are pulled into circular orbits transverse to the driving current). If the latter is correct, the first quantum transition is expected to occur at a field of 38 T. A strong increase in R was indeed observed[2] (see Fig. 4) at 38 T using the pulsed magnetic facility; this thus confirmed the S-dH interpretation. The higher order transitions observed in this experiment match very nicely those observed by the dc magnetic field facility at Grenoble.

Other activities of the group include studies of the magnetoresistance of the $(DMtTSF)_2X$ and $(TMTSF)_X$ families where the first evidence has been found in the former for weak localization in organic conductors and the first observation of oscillations periodic in 1/B for the latter. Finally, magnetoresistance studies of the purple bronze KMo_6O_{17} have shown that the cyclotron mass of the carriers is 1/10 that of a free electron.[3]

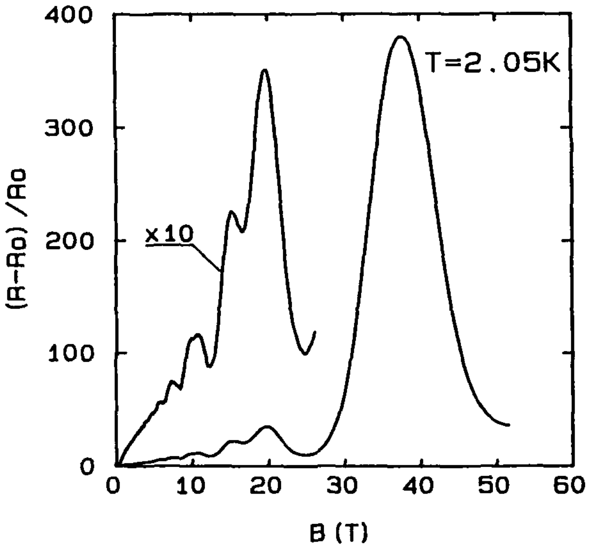

Fig. 4—Shubninkov-de Haas oscillations in the magneto-resistance of NbSe3 as a function of magnetic field

High T_c Superconductivity (HTS)

Does a Fermi surface (FS) exist in the new superconducting oxide materials and, if so, What are its features? These are fundamental questions because conventional (BCS) theories require a FS, whereas less conventional (exotic) theories actually exclude it. Several experimental techniques developed at this laboratory have been used to answer these questions. Michel Goiran (SNCMP) and scientists from the Naval Research Laboratory (NRL) are attempting to measure the effective mass (related to the FS) of the carriers responsible for conduction (thus, superconductivity) by using cyclotron resonance. Evert Haanappel and collaborators from the Max Planck Institute (Grenoble) and scientists from NRL have used the SNCMP 50 T facility to confirm the de Haas-van Alphen oscillations in YBaCuO observed at Los Alamos National Laboratory. Finally, Jean Claude Ousset and Harison Rakoto (SNCMP) have measured the magneto-resistance of several samples of REBaCuO (RE, rare earth) made and characterized at Toulouse[4] and at NRL.[5] They found that R(H,T) scaled with $\cos\theta$, where θ is the angle between the applied field and the c-axis of the crystal (Fig. 5). This result provides clear evidence for the existence of 2-D conduction in this system that is intrinsically related to a cylindrical FS.[6] This result also demonstrated that analyses of R(H,T) above T_c based purely on the Azlamasov-Larkin fluctuation theory are insufficient. Other interesting features of the magnetoresistance in the REBaCuO and other oxide superconductors are under investigation.

Magnetic Multilayers

What are the magneto-transport properties of thin magnetic layers coupled by metal layers? A group composed of Abdhala Sdaq, Jean Marc Broto, Harison Rakoto, and Jean Claude Ousset (all from the SNCMP) and two groups from the CNRS have been answering this question by using samples consisting of Co layers coupled by Cu layers of varying thickness, or by using samples of alternating layers of Ni and Ti. They observe an unusual decrease in the magnetoresistance as the field is increased (Fig. 6) that has not been explained.

Other activities of the group include studies of dilute magnetic semiconductors and nanocrystals of Fe, Ni, and Co.

Semiconductors

Jean Leotin leads a group that conducts magnetotransport, magnetooptics, and photoconductivity in the far infrared spectrum (wavelengths from 10 μm to 3 mm). Motivated by the need to use IR detection for the measurement, this group has developed highly sensitive detectors. An extension of the work is a collaboration with NASA.

The semiconductor systems investigated are AlAs-GaAlAs heterojunctions, $CuInSe_2$ and II-VI dilute magnetic semiconductors.

AlAs-GeAlAs: Despite the technological importance of AlAs, its conduction band effective masses are still controversial. Michel Goiran and Jean-Louis Martin have measured the cyclotron resonance in a two-dimensional electron gas in a type II heterojunction grown at the L2M CNRS in Bagneux. The experiment is now planned to be carried out under uniaxial stress to identify clear longitudinal and transverse masses.

$CuInSe_2$ (CIS): A promising candidate for solar cells, the resistance as a function of magnetic field and temperature of CIS is being studied by a group of collaborators at SNCMP (Professor Jean Leotin, Dr. Jean Galibert, and Dr. Lahcen Essaleh

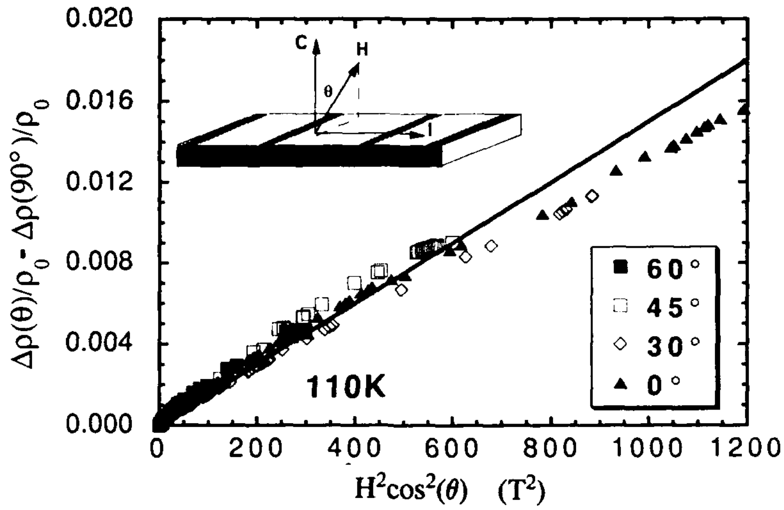

Fig. 5—Magneto-resistance of YBaCuO scaled as $\cos_2\theta$, where θ is the angle between the applied field and the *c*-axis of the crystal. This result provides clear evidence for the existence of 2-D conduction in this system, which is intrinsically related to a cylindrical Fermi surface.

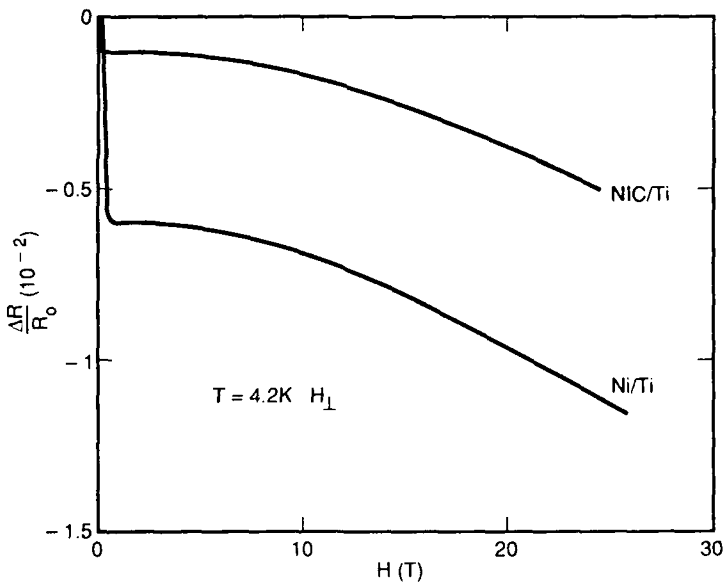

Fig. 6—Magneto-resistance of multilayers

(now at the University of Marrakech in Morroco)) and a visitor, Dr. Syed Wasim (Universidad le Los Andes, Venezuela). The system is being studied to fully understand its transport behavior. Depending on doping, it can exhibit either metallic, weak, or strong localization conduction behavior.

Far infrared spin resonance in II-VI dilute magnetic semiconductors: The exchange interaction between magnetic ions in a material is usually determined by using magnetization or Raman spectroscopy. Using another approach, the exchange interaction between nearest-neighbor magnetic ions (Mn, Co, Fe...) diluted in a II-VI compound lattice is investigated by studying the transmission of far infrared laser light through a sample as function of magnetic field and temperature. This experiment

is usually conducted at low magnetic fields (i.e., H < 20 T), in which case only one resonant absorption is observed. This resonance corresponds to the isotropic exchange interaction between a pair of nearest-neighbor magnetic impurity atoms. At the higher magnetic fields available at the SNCMP, satellite peaks, which are ascribed to the anisotropic exchange interaction between the same pair of nearest-neighbor magnetic impurity atoms, appear in the resonance. Figure 7 shows an example of the splitting observed at high magnetic fields for 5% Co doped ZnS. From such data, the Dzialoshinski-Moriya anisotropic constant *d* can be obtained, which for this materials is 1.5 K. The isotropic exchange interaction *J* can be derived from a study of the linewidth as a function of temperature. This experiment was performed by Michel Goiran, Jean Louis Martin, Jean Leotin (all from SNCMP) and Zbigniew Golacki of the Polish Academy of Sciences, Warsaw.

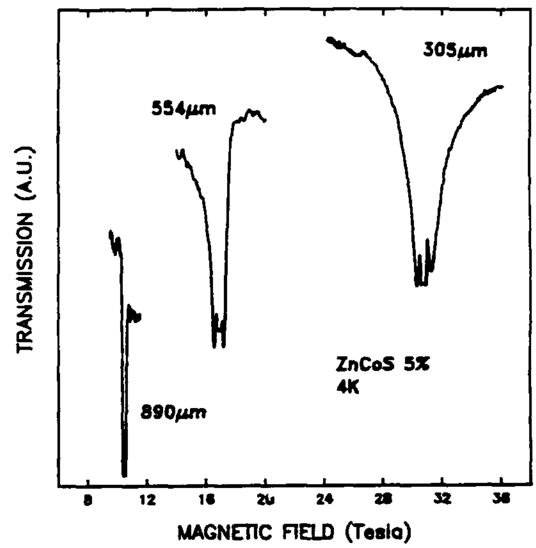

Fig. 7—Transmission of far infrared laser light through a sample of 5% Co-doped ZnS as function of magnetic field. Resonances reveal the nature of the spin interactions.

Infrared detectors: Blocked-impurity band, silicon-doped-with-antimony photodetectors (BIB Si:Sb) are developed for implementation in the focal plane of spaceborne instruments devoted to the spectroscopy of the atmosphere using far infrared emission. SAFIRE is a NASA instrument realized with European space agencies from the U.K., Italy, and France. Gilles Sirmain and Claude Meny are studying this new type of radiation-hardened photoconductor, which was first conceived at the Rockwell Science Center in the U.S. a decade ago.

FUTURE

The character of this laboratory directly reflects the nature of its director, Salomon Askenazy. He was the driving force behind the conception, planning, and construction of the SNCMP. Furthermore, he has been the inspiration of much of the work conducted here; in fact, all experiments have directly benefited from his involvement.

Askenazy, anticipating needs for the future, has been planning an expansion of the laboratory; indeed, construction of a new facility is imminent. It will have enlarged and improved laboratory space with 10 stations, additional office space, and a new bank of capacitors (weighing 100 tons!) that will store 12 MJ of energy. This scaleup in energy will have several benefits: a modest increase in the maximum achievable magnetic field (perhaps 70 T), significant enlargement of the bore size of

Table 2. Proposed Magnet Characteristics for New Laboratory

Maximum field (T)	35	42	50	60	70 ?
Stored energy (MJ)	12	12	12	12	12
Usable inner diameter (mm)	50	40	30	25	20
Inhomogeneity in 10 mm	6×10^{-4}	6×10^{-4}	2×10^{-3}		
Decay time (s)	10	6	4	1	0.4

the magnets, lengthening of the pulse time, and a very significant increase the coil lifetime. The proposed magnet characteristics are summarized in Table 2.

The design of these characteristics is founded on principles set out several years ago by Askenazy and collaborators.[7,8] They based their calculations of the critical magnet characteristics (e.g., geometry, magnetic field, rise and decay time, length, bore size, outer diameter) on simple physical arguments rather than on the straightforward albeit tedious computer calculations used by others. Askenazy's method accurately predicted the properties of the magnets already in use in the laboratory (Table 1), so they can be confidently used to predict the characteristics of the scaled-up versions to be constructed for the new laboratory. The group has also been developing new wires (greater strength and higher conductivity) to further improve performance.

CONCLUSIONS

From the perspective of visitors who have benefited from collaborations with researchers at Le Service National des Champs Magnetiques Pulses, we find the experience rewarding. The staff is very experienced in this role and make it especially easy for visitors to conduct research there. We highly recommend that others profit from the experience!

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Oceanography

Coastal Ocean Research at the Proudman Oceanographic Laboratory

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INTRODUCTION

This report reviews some of the oceanographic research undertaken at the Proudman Oceanographic Laboratory (POL). It is timely and important to the Office of Naval Research (ONR) because of the recent emphasis on research on the oceanography of shelf seas and POL's strong performance over many years in this area of research.

Proudman Oceanographic Laboratory is one of the research centers of the U.K. Natural Environment Research Council (NERC), and its research focuses on understanding the physical processes in the coastal oceans. Proudman Oceanographic Laboratory has a long successful history of its former directors, namely Proudman, Doodson, and Cartwright, doing high-quality research on ocean tides, and it continues to make the tide predictions for all U.K. harbors and nearby estuaries and shelves. Although some tide research continues to be performed at POL, most of the research now is oriented toward higher frequency waves, circulation, and sediments on the shelf. Proudman Oceanographic Laboratory is the leading U.K. center for research and development for surge predictions, and it supports operational forecasting models for the surrounding seas, which are run by the U.K. Meteorological Office.

The organization of POL is not complicated. The Director is Dr. Brian McCartney, and there are three major groups. A Marine Physics Group is headed by Dr. John Huthnance and a Technology Group by Mr. J.B. Rae. In addition, POL runs the British Oceanographic Data Centre (BODC), which is managed by Dr. M.T. Jones. Mr. Graham Alcock is the Commissioned Research Coordinator; he coordinates all non-NERC contract research done by POL, handling interactions with present and potential sponsors. There also is a technical library and a small section of the NERC computer services. In all, POL has about 90 personnel, about 60 of whom are scientific and technical, and the annual budget is about $7M. The Laboratory is collocated with the old Bidston Observatory in a modern building on a hill overlooking the Mersey Estuary and the Irish Sea.

The history of POL is intertwined with that of Bidston Observatory, which was founded (as the Liverpool Observatory) in 1845. The Observatory's principal objective was improving the determination of longitude (at that time, done by a combination of accurate time and astronautical observations). In 1924, tidal predictions were begun at the Bidston Observatory, and in 1929 the Liverpool Observatory and Tidal Institute was formed, with two tide-predicting machines (basically mechanical computing machines) being put in use. This institute became a component of NERC in 1969, and honored one of its most famous directors in 1987 when it became autonomous within the

Marine Science Directorate of NERC and was renamed the Proudman Oceanographic Laboratory. The name is after Joseph Proudman, a former Director who was famous for his work on tides and an early treatise on dynamical oceanography. During 1969-1987 the laboratory was named the Institute of Coastal Oceanography and Tides and, although the official title was changed in 1987, this title still describes the focus of the work at POL.

MAJOR RESEARCH PROJECTS

The Marine Physics Group is organized by project, with the major projects being funded by NERC over multiple years. Dr. Huthnance directs the North Sea Project, which is winding down after five years of intensive work; the Shelf Sea Dynamics Project, which is in midlife; and the Land-Ocean-Interaction-Study, which is just beginning. In addition, a sea level and tides project from NERC is headed by Dr. T. Baker and an effort in sea level studies is headed by Dr. Philip Woodworth. Dr. Alan Davies, Dr. David Prandle, and Dr. Roger Flather are NERC Senior Scientists and are not directly responsible for managing projects, but they also work in these areas.

1. North Sea Project (NSP)

The North Sea Project is a 5-year NERC Community Research Project for which POL has lead responsibility as the host laboratory. It is presently winding down. However, it is useful to review this project because it is representative of the research at POL. Work has been coordinated with three other NERC laboratories, ten university departments, the Research Vessel Service, and NERC Computing Service and has involved about 200 scientists and support staff over the five-year life of the project.

The overall objective was to establish a basis for prognostic environmental quality models that would be suitable for aiding in management of the North Sea. Some specific goals included constructing a transport model, determining nonconservative processes, and measuring a range of parameters over more than one annual cycle.

Results are available in many papers to date, with many more yet to be published. An aperiodical newsletter has been published by POL to keep all interested parties informed as to plans, important meetings, and quick-look results.

Surveys

Fifteen monthly cruises were coordinated by Mr. John Howarth of POL on the RRS *Challenger* between August 1988 and October 1989. These each included a 12-day survey over 1800 nautical miles in roughly a triangle from Dover Strait to 55°30'N from England to the German Bight. Also, each included a 14-day process study aimed at one of the goals. Each survey included approximately 100 conductivity-temperature-depth (CTD) profiles, and maintenance of 6 current meter moorings. Some of these moorings had current meter strings and others had bed-sited acoustic doppler current profilers (ADCP), which provide a nearly continuous vertical profile of the horizontal current. In addition, the ship made continuous surface temperature and salinity measurements and continuous velocity profiles with an ADCP. The latter data set turns out to be very interesting because it provides some insight to the vertical structure of the smaller scale eddies and fronts. Measurements from other laboratories included suspended sediments, benthic fluxes and sediment characteristics, cores, many biogeochemical constituents (dissolved oxygen, nutrients, chlorophyll-a, phytoplankton, primary productivity, zooplankton, biogenic gases), trace metals, and air-sea fluxes. Some of the measurements were made in a continuous mode, while others were made in the traditional way of getting samples of water and making the analysis onboard the research vessel.

The high density surveys are being followed by a series of three annual surveys over the same track in May and September of each year. Also, in a closely connected project supported by the Department of Energy, data are being extended further into the Dover Straits by monthly cruises and continuous measurements for one year with a bottom-mounted current profiler, sediment load measurements, and an area-covering shore-based high-frequency ocean surface current radar (OSCR).

The resulting data set on a semi-enclosed, shallow sea is unique and should be a valuable resource for research in the near future. Also, it is hoped by all that future surveys of this type will

be able to make continuous profiles while underway from a towed undulating profiler instead of stopping the vessel to make the profiles as was done for most of these surveys.

Process Studies

Process studies are coordinated measurements that are made to better understand specific oceanographic processes in limited regions of the ocean. Such studies in the North Sea Project were aimed at ocean fronts, sandwaves, sandbanks, and sediment resuspension. One study was made of a nearshore front by making CTD casts and ADCP measurements from the vessel in coordination with OSCR, a current meter array, thermistor strings, and a surface wave buoy. A surface current convergence of 4 cm/s was found, a phenomenon that is known to be associated with downwelling at the front.

Another study that was the subject of four cruises was aimed at the circulation and mixing in the Flamborough Front, which is more apparent near the bottom. This time the ADCP was used in conjunction with a towed undulating vehicle carrying the CTD. Of special interest were the evolution of the front over a tidal cycle and the variance in the upper layer as the result of wind-driven flow. The tidal current, particularly the ellipse orientation and the phase, are affected by water stratification near the front.

Evolution of the fresh-water plume from the Rhine outflow was sampled in collaboration with German and Dutch scientists, and a detailed biogeochemical data set is being studied for effects of lateral and vertical mixing.

A number of cruises studied bottom morphology, sediments, and the transport of bottom materials. Form drag and skin friction were estimated over sand waves on three cruises. On another, the nature of the larger scale flow around sand banks was studied by using current meters, a side scan sonar, and a fluorescent method of determining sand movement. Finally, on three cruises, sediment resuspension was studied by a combination of transmissometers, sediment traps for settling velocities, and detailed analysis of characteristics of suspended particulates.

Modeling

A number of available numerical models have been applied to this project, and others have been constructed specifically for it. Some of this work has been done in conjunction with the Joint North Sea Modelling Group (JONSMOD) and some by POL investigators alone in this NERC project.

A two-dimensional (2-D) "general-purpose" model that uses depth-integrated quantities and simple physics has been exercised to simulate distributions of various constituents, for studying formulations of physical processes in mixing and dispersion, and in setting up three-dimensional (3-D) models of the temperature, salinity, and circulation fields. This model has been widely used by scientists in other disciplines at other institutes in the project; examples include calculations for the transport of sediments, chemical constituents, and fish larvae. It has been applied to study the transport and dispersion of cesium released from several known sources, including Chernobyl.

A 2-D field of currents has been computed for the 15-month period of dense observations by a combination of the POL tide-surge model and the predictions from the operational 37-km-resolution storm surge model. This field is being compared with the current meter and profiler data sets from this project, and it is providing the basic input to an advection-dispersion model for observed nutrients.

Several 3-D models are being developed, and model outputs are being compared with data. The purpose of one of these models is to simulate seasonal cycles of phytoplankton, detritus, combined nitrogen and oxygen, and sediment load. Another is to better resolve the 3-D circulation in the North Sea. Progress is being made on a 22-km model (in combination with scientists from the Institut fur Meereskunde, Hamburg) of the seas surrounding the British Isles and a 3-km model of the region of monthly surveys. The former has been used to calculate a monthly climatology of the circulation. It also will be used to embed the higher resolution model, which will include frontal model dynamics, tidal advection, improved vertical diffusion, revised open boundary conditions, initialization by dynamically balanced fields, and use

of observed winds, river inflows, and surface heat fluxes.

2. Dynamics of Shelf and Slope Seas

This is a NERC Laboratory Research Project, which means that the work is primarily done within POL. It builds on the history of work at the Laboratory on tides and surges on the shelves surrounding the U.K. The general objective is to identify, measure, interpret, and formulate predictive models of physical processes in continental shelf and slope seas, especially in relation to sea levels and current structure, and to transfer the developed methodologies to the appropriate authorities. The specific multiple goals are to:

- develop a joint wave-tide-surge forecast model,
- synthesize variations observed in vertical structure of currents, and
- develop 3-D predictive models of fine-scale phenomena in shelf-edge contexts.

This project builds on the history of work at the Laboratory on tides and surges on the shelves surrounding the U.K. It is very ambitious because it brings together the three components that, to first order, are independent. It is expected that the wave model will depend on actual water depth and current velocity, while the surge-tide model will accommodate radiation stress of the waves in an interactive manner.

A surge forecast model presently is run at the U.K. Meteorological (Met) Office to provide warning of flood conditions that are prevalent during winter storms. This model was originally constructed by POL, and it continues to be maintained by them. It is being upgraded under this project to input wind and pressure data from the Met Office's new limited-area weather forecast data that has 12-km resolution. The improved model presently is being tested, and trial runs have been made with specific recent storms that have caused flooding. In addition, comparisons of this model are being made with other European models including Dutch, French, Belgian, and Greek ones.

In a special, quick-reaction study initiated during the Persian Gulf war, a model was constructed for predicting currents, particle trajectories, and dispersion of oil in the Arabian Gulf. The model predicts depth-mean currents with 5-km resolution and 10 tidal constituents and uses the Met Office wind and pressure from their global weather forecast. An oil spill model from the University College of North Wales was added to predict the spread and dispersion (including sinking) of the spilled oil. This is being published in *Continental Shelf Research*, and it will be interesting to see how these results compare with similar models constructed in the U.S.

Dr. Xiao Ming Wu is working to improve the 2-D storm surge model and is using the Celtic Sea as a test region. Because of the shallow depths (generally less than 55 m), surface waves add to the bottom stress. He therefore uses the most recent European third-generation numerical wave model (WAM) to calculate the waves, and then uses the waves to recalculate the bottom drag in the surge model. Model runs so far indicate significant surge height differences, especially in the shallow estuaries.

Dr. John Huthnance has had a long-term interest in currents and processes along the shelf edge. Because of the abrupt change in topography, the edge (i.e., the vicinity of the shelfbreak and upper continental slope) is the location for ocean fronts, intensified currents, propagating long waves, and nonlinear internal wave generation. He has recently written a paper that reviews present theory and observations, and then infers the requirements for numerical models that are needed to realistically integrate the processes. He focuses on low-frequency motion (i.e., about the inertial period and longer), and thus uses coastally trapped waves—potential vorticity waves that propagate along the shelf cyclonically when viewed from the open ocean—as the basis for setting model requirements. These waves are a natural basis for wind or buoyancy driven flows, and adjustment between open ocean and shelves. The regional extent of the model may have to be asymmetrical, since the downstream boundary might be only 100 km away but the upstream (up-shelf!) boundary might need to be 1000 km away. Stratification is important on all shelves sometimes, and a simple two-layer approximation has been found inappropriate to get the waves qualitatively correct—so good vertical resolution is required. Some (much?) of the transport from the coast to the open ocean (i.e., the

cross-shelf component) may occur in the frictional bottom boundary layer, so 3-D flow, including a realistic boundary layer, is needed. Grid resolution must be sufficient for at least the internal deformation radius (about 5 km), but it must also resolve the depth gradients well to accurately capture the coastally trapped wave properties. Additionally, there is evidence that abrupt bathymetric features are important for energy losses due to scattering, so the computational grid must resolve such features accurately. In summary, he assesses that accurate numerical modeling of physical processes at the shelf edge is a challenging area of research, but the knowledge exists to estimate the model requirements.

Dr. Alan Davies has long specialized in numerical hydrodynamic models of shelf seas. A recent interest has been the formulation of the bottom boundary condition. He has found that a simple eddy viscosity formulation for the bottom is adequate for above-bed tidal currents, but that a turbulent energy closure scheme produces more accurate near-bed currents. He is presently investigating the addition of surface waves, which add considerably to the bottom stress in shallow water, especially during strong storms. The bottom boundary layer is interesting, and not only for its role in modifying the interior flow above it. Sediment mechanics, benthic ecology, and cross-shelf transport (net interior flows tend to be along-shelf, boundary layer flows cross-shelf) all require details of the bottom boundary layer.

3. Sea Levels, Ocean Topography, and Tides (SLOTT)

The SLOTT project is a NERC Laboratory Research Project whose emphasis is on research into sea levels on a global scale, particularly those aspects relating to climate change. As such, it is a U.K. contribution to an international program to determine the secular trends in mean sea levels and to assess the rise of sea level due to the greenhouse effect. This is much more complicated than just measuring sea levels; movements of Earth's crust also are important.

The Permanent Service for Mean Sea Level, headed by Dr. Philip Woodworth, is an archive of mean sea level measurements that was established at Bidston in 1933. It is funded jointly by this project and international services, and it maintains an archive of data from all international sources. This effort is important to researchers worldwide because it is the basis of most estimates of global and regional changes in the sea level over the past century. Most of the upward curves that you might have seen in the news that have any international flavor are connected with this project.

A global network of about 300 primary tide stations, which is part of an international program called Global Level of the Sea Surface (GLOSS), is the focus of POL in this project. The specific part supported by this program is called the Antarctic Circumpolar Current Levels from Altimetry and Island Measurements (ACCLAIM), and POL's contributions include a tide gauge network of bottom pressure recorders in the South Atlantic, performance of research, and provision of training courses for foreign tide gauge operators. One of the research projects associated with this observation network is comparing measured sea level variations with GEOSAT altimeter data in the South Atlantic and Southern Indian Oceans. For monthly time scales and longer, there is good agreement to several centimeters, just as is found by U.S. investigators for Pacific islands. In addition, the altimeter data are being analyzed for wave information on seasonal time scales for the eastern North Atlantic, and the results will be compared with predictions of a third-generation numerical wave model (WAM).

One important application of open-ocean tide information is the removal of tide constituents from satellite altimeter (such as GEOSAT) data, so that the residual ocean surface level can be analyzed for the mesoscale signal associated with fronts and eddies. This removal of the tide signal is performed with a model that, in the U.S., has been the Schwiderski model from the Naval Surface Warfare Center in Dahlgren, Virginia. Dr. Roger Flather of this group has constructed an ocean tide model of the Northeastern Atlantic; this has produced significant differences from the Schwiderski model in the vicinity of the Iceland-Faeroes ridge. This model markedly reduces the variance in sea level in this region, in conformance with oceanographic knowledge regarding the small density changes across this particular front.

As a direct result of the motivation of removing tides from altimetric data, Dr. David Cartwright (the former Director of POL, now in the U.S.) has been able to successfully invert this process such that accurate open-ocean tides are now being derived from satellite altimetry.

TECHNOLOGY DEVELOPMENT

Scientists at POL have constructed and used acoustic doppler current profilers for some years, building on initial developments by the Institute of Oceanographic Sciences Deacon Laboratory in Wormley. During the North Sea Project, six of these instruments were constructed and used in a total of 46 deployments. These are 250 kHz, 2-beam designs that are placed on the bottom, with upward-directed beams that measure the horizontal velocity profile from the surface to the bottom by using the doppler shift in the volume reverberation profile. In addition, a 1 MHz system has been designed and deployed to measure the water velocity in conjunction with sediment measurements in shallow water, and a 3 MHz unit has been designed to measure the sediment load from the level of the reverberation. Initial thought has gone into developing a multiple frequency version of this instrument to estimate the size distribution of the sediment load. In preliminary research for doing this, laboratory measurements have been made with a suspension of glass spheres to study the effect of multiple scatterers in the illuminated volume. Finally, in this area of acoustical oceanography developments, very good correlations have been obtained from simultaneous measurements of the acoustic reverberation level and an optical transmissometer in the Dover Straits.

This acoustic instrumentation is mounted for use at sea on a platform called Sediment Transport and Boundary Layer Equipment (STABLE). This is a bottom-mounted tripod that contains many instruments and operates independently after deployment. It has sensors to measure the 3-D turbulent velocities in the bottom boundary layer, a vertical string of 2-D current meters, an optical backscatter sensor, and an optical transmissometer. On one occasion, the acoustic backscatter system discussed above was deployed on STABLE with simultaneous frequencies of 1, 2.5, and 5 MHz.

Proudman Oceanographic Laboratory is one of a small number of laboratories that are developing a surface wave measurement technique by using a scanning X-band navigation radar. In this case, the video data from the geographical display are stored and processed later. Of course, the data represent only the radar cross section variations, but the 2-D spatial spectrum of the cross section modulations provides their wavenumber content. When used in conjunction with a surface wave buoy that provides the frequency content, they obtain reasonable graphical expressions of the directional wave spectrum.

Proudman Oceanographic Laboratory also has one of the few available ocean surface current radar (OSCR) instrumentation suites,[1] and it has proven to be extremely valuable in coastal regions because the data have exhibited a rich mixture of physical features that make up the time varying and residual currents. Proudman Oceanographic Laboratory has improved the utility of this instrument to scientists by considerable development in the processing and display software. The hardware and this enhanced software are available on license through the manufacturer of the hardware (Marex Ltd).

BRITISH OCEANOGRAPHIC DATA CENTRE (BODC)

The BODC was formed in 1989 from the Data Banking Section of the Marine Information and Advisory Service. Its goals are to:

- provide data management support for U.K. marine science,
- maintain and develop the U.K.'s national oceanographic database,
- make high-quality oceanographic data available to U.K. research scientists, commercial users, and local and central government departments, and
- collaborate on U.K.'s behalf on international exchange and management of oceanographic data.

The Centre develops data products, including digital atlases, and provides support for scientists in the processing and quality control of their data. The focus is on data management for the NERC Community Research Projects, with current ones

being the North Sea, Biogeochemical Ocean Flux Study (BOFS), and the U.K. World Ocean Circulation Experiment (WOCE). As an example, a CD-ROM will soon be available that includes all data collected during the North Sea Project. This data set has more than 3,800 CTD casts, 10,000 water bottles (with up to 40 measured parameters), 750 net hauls, 168 production experiments, 59 sediment cores, and 70,000 nautical miles of underway data. The underway data include 16 cruises with ADCP, 8 cruises with nutrients, 20 cruises with dissolved oxygen, and all with thermosalinograph, fluorescence, transmittance, bathymetric depth, light, and irradiance. The data set also will include time series data for moorings and a North Sea bibliography of 7,500 references. A sequence of sea-surface temperature images for the entire period of the project is being developed, and also will be available near the time of publication.

A PC-based atlas and information system for all data on the seas around the U.K. (called UKDMAP) has been developed and is available. The atlas includes interactive graphics for displaying thematic maps of environmental conditions, fisheries data, and a number of other quantities.

Under European Community MAST I (Marine Science and Technology) funding, BODC has collaborated with 10 other European countries to carry out a feasibility study for a European network for oceanographic data, to be called the European Ocean Data Analysis Network (EODAN). It was recognized that such a network would improve the availability and management of marine data for all of Europe, and would assemble data sets for all the surrounding seas. A report now is available, with the inevitable conclusion that scientists now should have data collections for all European seas readily accessible on their workstations. Although unspoken, there also inevitably must be a high level of jockeying to see what country can attract the funding to take the lead in performing this service.

BODC is developing a European Directory of Marine Environmental Data as a PC-based referral system for the primary marine data collections currently held in European laboratories. It already has a catalog of moored current meter data collected by laboratories in Europe and North America (called the International Current Meter Inventory). The catalog is distributed on floppy disk complete with a menu-driven interface for browsing (with convenient geographic plots), selection, manipulation, plotting, and printing on a PC.

APPLICATIONS

Research at POL continues to support applications that are funded by the Ministry of Agriculture, Fisheries, and Food (MAFF) among others. Proudman Oceanographic Laboratory Applications is a section set up to provide predictions of tides and currents, to reduce and analyze sea level and tidal current records, estimate extreme levels, and maintain the climate station at Bidston. This section provides support for other research projects within the laboratory and answers commercial and noncommercial inquiries concerning tides and meteorology. It maintains and updates a library of the harmonic constants that are used in the tide predictions for all major U.K. harbors as well as many foreign ports. Finally, it carries out the tide calculations and provides tidal prediction tables for publication in the Admiralty Tide Tables, Port and Water Authority handbooks, almanacs, and fishing and sailing literature.

FUTURE

An emerging NERC Community Research Project is the Land-Ocean-Interaction-Study (LOIS), which is a major U.K. thrust in coastal oceanography for the next 5 years or so. Proudman Oceanographic Laboratory will play a leading role in LOIS, but many laboratories and universities are involved. At the present planning stages, LOIS is defined very broadly and has very ambitious goals. The main products expected from LOIS are:

- integrated environmental databases from selected sectors of the U.K. coastal zone incorporating measurements of material fluxes and biological productivity;
- quantitative information about the cycling of carbon and other biologically important elements in the coastal zone, in relation to the impacts of land use, eutrophication, and waste disposal;
- a new capability for developing coupled land-ocean models to predict impacts of

environmental change in the coastal zone; and

- tested simulation models of fluxes of sediment, nutrient materials, organic matter and pollutants across the land/sea and shelf/ocean boundaries.

These ambitious products will be achieved by addressing equally ambitious goals:

- to characterize and measure the contemporary fluxes of energy and materials into the coastal zone from the land by way of rivers and groundwater, from the atmosphere and from the ocean;
- to identify and quantify the physical, chemical, biogeochemical, and biological transformation and recycling processes in river basins, the atmosphere, and inner shelf seas, and at the shelf edge zone, that govern such fluxes to and from the coastal zone;
- to provide long-term perspectives of energy and material fluxes that affect river basins, the coastal zone, and the wider shelf sea on a range of time-scales: the last 200 years, the last two millennia, and the Holocene period as a whole;
- to initiate the development of coupled land-ocean models of environmental change in the coastal zone that, by combining an understanding of contemporary behavior and past trends, will provide the basis for predicting the impacts of environmental change over the next 50-100 years.

LOIS is divided into four components, which overlap somewhat: River basins Atmosphere Coast and Estuaries (RACS), Shelf Edge Study (SES), North Sea Modelling Study (NORMS), and Land-Ocean Perspective Study (LOEPS).

RACS will initially focus on the east coast of England on the North Sea north of Great Yarmouth, where there is substantial river inflow and coastal erosion. Components will include river basin studies (hydrology, sedimentology, biogeochemistry, and contaminants), the atmosphere (pollutant gases, fluxes of gases and aerosols at the sea surface), coupled nitrogen/sulfur chemistry and transport, and regional model construction), coast and estuaries (seasonal and interannual variations in physical and ecological systems, long-term observations at boundaries, seasonal synoptic surveys, and precise flux estimates), and modelling (atmosphere transport models, user-friendly process models for general community use, and coastal ecosystem models incorporating terrestrial, atmospheric, and marine effects on the biology and geomorphology). Although RACS seems like an impossible wish list, actual planning is directed toward tractable subsets of these goals. For example, David Prandle is helping to plan a sediment budget experiment in the RACS area. The objective of the experiment will be to understand the processes that are responsible for moving the very large amounts of sediment (coastal erosion rates exceed 1 m/y) southward over the inner shelf. Questions include: How much sediment is lost to the outer shelf? What do episodic events contribute to the sediment transport?

SES will continue work already started by John Huthnance on the Hebrides shelf edge. Previous work was mostly physical, but SES will incorporate multidisciplinary elements to examine the shelf-ocean exchange of biogeochemical materials as well. During 1993-1995, a combination of fixed moorings (current meter, ADCP, bottom tripods), ship surveys (SeaSoar and ADCP, 8 cruises of 28 days), and drifting buoys (some with chlorophyll and nutrient sampling) will be used. One unique aspect of the program will be a planned release of technetium (a long-lived radioisotope that remains in solution) into the Celtic Sea. The gross flux of technetium across the shelf edge will provide a unique integral constraint on shelf-ocean exchange. The dynamical aspects will concentrate on model building, beginning with simple process models but with the ultimate goal of 3-D *prognostic* models.

NORMS is an extension of the successful modeling in the North Sea Project. Preliminary plans envisage a 3-km-grid hydrodynamic model for the central and southern North Sea (encompassing the RACS region), and for the shelf edge. An ambitious extension would be a North Sea model capable of including important biological and chemical components, and responding to fluxes at the boundaries and internal processes. Two types of nearshore models are envisaged: an ecological model that could incorporate human impacts, and a

geomorphological model that could simulate erosion and accretion at the coast. It seems likely that these last two model types will contain significant empiricism for the foreseeable future.

The LOEPS is designed to provide a long-term context for the other LOIS studies. Its goals are to study the Holocene sedimentary record to understand how sediment fluxes have responded to sea-level, climate, geomorphological, and land-use changes; determine the regional history of sediment fluxes, especially the relative importance of fluvial, coastal, and sea-bed sources; and to determine the biological influences on sediment fluxes.

SUMMARY

The Proudman Oceanographic Laboratory is a center for coastal ocean physical science in the U.K., and the investigators concentrate on a diverse set of physical problems. They have strong links with applied issues, such as tides, storm surge, and wave predictions, and they collaborate with many other U.K. and European research centers on major ocean research programs in these areas. Much of this work is significantly advanced, and it is important for U.S. programs in ocean dynamics on shallow shelf seas to be aware of the progress of the research at this center and to collaborate with these scientists in specific areas of interest.

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Investigating a Possible Submarine Volcanic Eruption by Using Russian Mir Submersibles: Implications for Cooperative Work

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KEYWORDS: Reykjanes Ridge; mid-ocean ridge(s); ground-truth; submersibles; seismic swarm

THE CHANGING OCEAN FLOOR

The axis of the Mid-Ocean Ridge is the locus of new oceanic plate formation (spreading). It is the most active part of the ocean floor—both tectonically (faulting) and magmatically (volcanic eruptions)—and is susceptible to major changes. Tectonic and eruptive events are responsible for creating and changing the physical, chemical, and thermal characteristics of the ocean floor and water column. Many small-scale plate boundary events combine to create the ocean floor we map and study. Morphologic variables that are easily changed include the size and magnitude (amount of offset or surface rupture) of faults, thicknesses and continuity of sediment cover, and percentage of the seafloor covered by rough (unsedimented) lava surfaces. These variables affect the physical and

acoustic character of the ocean floor as measured, observed, and interpreted from surface ship geophysical surveys. Hydrothermal vents affect the chemical and thermal budgets of the oceans and are responsible for locally rapid sedimentation on young crust. Alteration of new lava surfaces will also affect the chemistry of the ocean waters.

Although marine geophysicists have a general understanding of the causes and effects of changes on the mid-ocean ridges, we have little data on the frequency and magnitude of these events. A more thorough understanding of the manner in which the mid-ocean ridges build ocean crust and evolve will allow us a greater ability to extrapolate and model the older parts of the ocean floor.

BACKGROUND TO THE EXPEDITION

The Naval Research Laboratory's (NRL) Mir submersible work is part of a chain of studies supporting the Inter-RIDGE (International Ridge Inter-Disciplinary Global Experiments) initiative to study geological and geophysical events along the world's Mid-Ocean Ridge in a timely manner. The Reykjanes Ridge is located astride the robust Iceland hotspot and comprises the northern part of the slow-spreading Mid-Atlantic Ridge (MAR) (~ 11 mm/year half-rate at 60° N).[1] The Reykjanes is not a typical spreading ridge.[2]

The survey area was centered around 59°50′ N, approximately 400 km from Iceland, along the axial crest of the Reykjanes Ridge. It included two en echelon volcanic ridges (2-3 km wide, 120 km long), which typify the crest of the regional Reykjanes Ridge. The dive site was selected because a seismic swarm was detected here in May 1989 by the Icelandic seismic network and the WWSN (World-Wide Seismic Network).[3,4] The location and magnitudes of these events were determined in June 1989 by using aircraft-deployed sonobuoys.[5] During the summer of 1990, a one-day mapping survey[6,7] of the area around the teleseismic swarm was made with National Science Foundation funding. The survey was made during a transit from the U.S. to Iceland aboard the Lamont-Doherty Geological Observatory (LDGO) ship the R/V *Maurice Ewing* while on an NRL-led research cruise. The SeaMARC II/Hydrosweep survey mapped an area extending about 10 km toeither side of the Reykjanes Ridge axis, imaging more than 7 individual en echelon axial volcanic ridges. It included numerous faults, fissures, small volcanic cones, and at least three fields of strong acoustic backscatter that extended up to 5 km off-axis. These fields were interpreted to be young lava flows with rough surfaces not yet covered by sediment.[7]

One of these high-backscatter fields was located near the sonobuoy-determined location of the 1989 teleseismic activity and was proposed as a possible site of recent eruptive activity.[7,8] In June 1992, five U.S. and 10 Russian scientists used the Mir submersibles, operated by the Laboratory of Deep Manned Submersibles of the Shirshov Institute of Oceanology in Moscow, to investigate one of these high-backscatter features.[9]

MAPPING AN ACTIVE OCEAN FLOOR

Marine scientists typically use remote instruments (sidescan sonar, swath bathymetry, satellite data) to survey the ocean floor. Small areas of the ocean floor (100-400 km^2) are surveyed in this way, and the structure of the seafloor is interpreted from compiled maps and images. These data are then extrapolated from surveyed areas (less than 10 percent of the total ocean floor) to unsurveyed areas.

To ensure that the original interpretations are accurate and to limit the inaccuracy introduced during extrapolation, representative areas must be studied in detail to provide "ground-truth" for the remote images. One example of enlightening ground-truth was immediately evident from our Mir observations. The patch of high acoustic backscatter, imaged by the sidescan sonar and thought to be a young lava flow[7,8] was inspected during our first dive. It was found to be a flat region of seafloor covered with 20-40 cm of sediment.[9] Although evidence for recent tectonic activity was present, the area was not a young (less than a few years) lava flow. Thus the acoustic energy, which revealed the high backscatter area, must have easily penetrated 20-40 cm of sediment, thereby revealing an older lava flow beneath its surface. This shows quite clearly that SeaMARC II's side-looking sonars can penetrate sediment through one to two wavelengths of the sonar frequency (11-12 kHz) and reveal the volcanic seafloor below. These findings led us to conclude

that the teleseismic swarm likely was caused by faulting or perhaps intrusive, not extrusive, activity farther to the east along the ridge crest and that we must use additional caution when interpreting sidescan images.

Our observations of the Reykjanes Ridge near 59°50′ N show that it is formed by extensive pillow lava flows and covered by minimal sediment (1 m or less). Abundant particulate matter is present in the water column, and up to 60 percent of the surface of some rocks is covered by encrusting sponges, sponges, corals, barnacles, brittle stars, and clams. Sediment cover ranges from < 1-2 cm along ridge tops, with small ponds of 15-30 cm between pillow lava outcrops, to > 1 m in the overlap basin between two axial volcanic ridges. On the basis of sediment cover across fault scarps and cracks in sedimented areas, it appears there has been recent tectonic movement within the dive area. Fault trends and relative sizes agree well with interpretation of SeaMARC II sidescan. Preliminary interpretation of conductivity, temperature, and depth (CTD) sensor data suggests that colder water on the western side of the ridge flows eastward through the basins between axial volcanic ridges and interfingers with warmer water to the east. A potential temperature difference of 0.2 °C makes it very difficult to distinguish hydrothermal phenomena, whose signatures in the water column (away from active vents) are more commonly in the 0.02 °C range. Fresh lava was found at only one location near the southern end of the northern axial volcanic ridge (59°52.4′ N, 29°38.8′ W, 1100 m). This young flow lacks sediment and biological cover and exhibits minimal alteration of the glassy rind. We believe it is less than 10-20 years in age, and might have been erupted during the 1989 swarm. No analytical data presently exist to support this claim. No other young lavas or evidence of recent volcanic or hydrothermal activity was discovered.

LIMITED SEAFLOOR SURVEY RESOURCES AND THE MIRS

As with many things, there are a limited number of surveying tools (ships, sonars, submersibles,...) and a limited amount of money available to support seafloor mapping research. Surveying tools are usually allocated to those (groups or individuals) who have obtained funding for a specific project. Funds are usually allocated by a competitive process between the researcher and the funding organization. The long lead time (typically 4-5 years or more from idea to field work) allows long-term planning for the most efficient use of scarce and expensive survey tools. In some cases, however, such as the earthquake swarm on the Reykjanes Ridge[5] or the magmatic eruption on the East Pacific Rise,[10] a more rapid response is appropriate. It is important to study seafloor features soon after the active period in order to avoid confusion with later events that may lead to false conclusions regarding the event. For example, faulting could cover the surfaces of young flows, with older rubble and sediment masking the true age of the area. In these cases, the use of "ships of opportunity" and a mechanism for rapid funding allow high-quality science to be done before the opportunity slips away. It was such a process that allowed us to dive on the 59°50′ N site within three years of the eruption. Alvin (the primary U.S. research submersible) would not have been available for the North Atlantic until at least 1995 or 1996. The Mirs became available to us at a very reasonable cost because of a strong commitment to original science by the Laboratory of Deep Manned Submersibles and a desire to participate in joint ventures.

The Mirs and their support ship, the R/V *Akademik Mstislave Keldysh*, comprise the best-equipped and most able research tool for detailed deep-sea research. We were quite pleased with the performance of the Mirs, the *Keldysh*, the Russian scientists, submersible handlers, ships crew, and especially the highly trained submersible pilots that helped us accomplish our project. [The following is not intended as an exhaustive comparison of research submersibles; it is simply a comparison of the Mirs with the two other submersibles with which one of the authors (LEJ) has personal experience.] In terms of cameras, sonar, radar, and navigation, the Mirs are equivalent to the Alvin or the Shinkai 6500 (a Japanese research submersible). The Mirs, however, have some unique capabilities that, for some applications, make them a better deep-sea research tool than either the Alvin or the Shinkai 6500. The Mirs dive together, allowing simultaneous two-submersible operations and immediate rescue assistance. The Mirs are

capable of diving to a depth of 6000 m—deeper than Alvin (4000 m) and similar to the Shinkai 6500 (6500 m). The sampling capability of the Mirs allows rock samples up to 70 pounds to be selected and individual biologic organisms to be delicately handled. The biggest advantage of the Mir operation is the increased on-bottom time. The Mirs are capable of working on the bottom with full lights for 10-15 hours. Alvin's bottom time is typically 5-7 hours, and light availability is limited for longer dives. The Shinkai is limited to 3-4 hours of on-bottom time.

To efficiently use the limited and expensive seafloor mapping resources and to accomplish studies of potentially active (or recently active) regions of the world's mid-ocean ridges, cooperation among all marine research groups from all nations is imperative. This is one of the goals of the InterRIDGE program and will require both continued long-term planning and scheduling of research expeditions and the flexibility to use available resources to study areas of immediate interest. The present disarray in the scientific community of the former Soviet Union means that some of their deep-sea mapping resources are available, often at minimal hard-currency costs, to the U.S. and other nations' research communities. We encourage use of these resources, both to help our colleagues from the former Soviet Union maintain research programs and resources during these difficult times, and to accomplish good science we would otherwise be unable to achieve.

Our expedition with the Russian submersibles shows how flexible and cooperative projects can result in new findings. Such cooperative projects not only foster good working collaborations, but make good use of scarce seafloor survey equipment.

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